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ONE YEAR THREE FIFTY

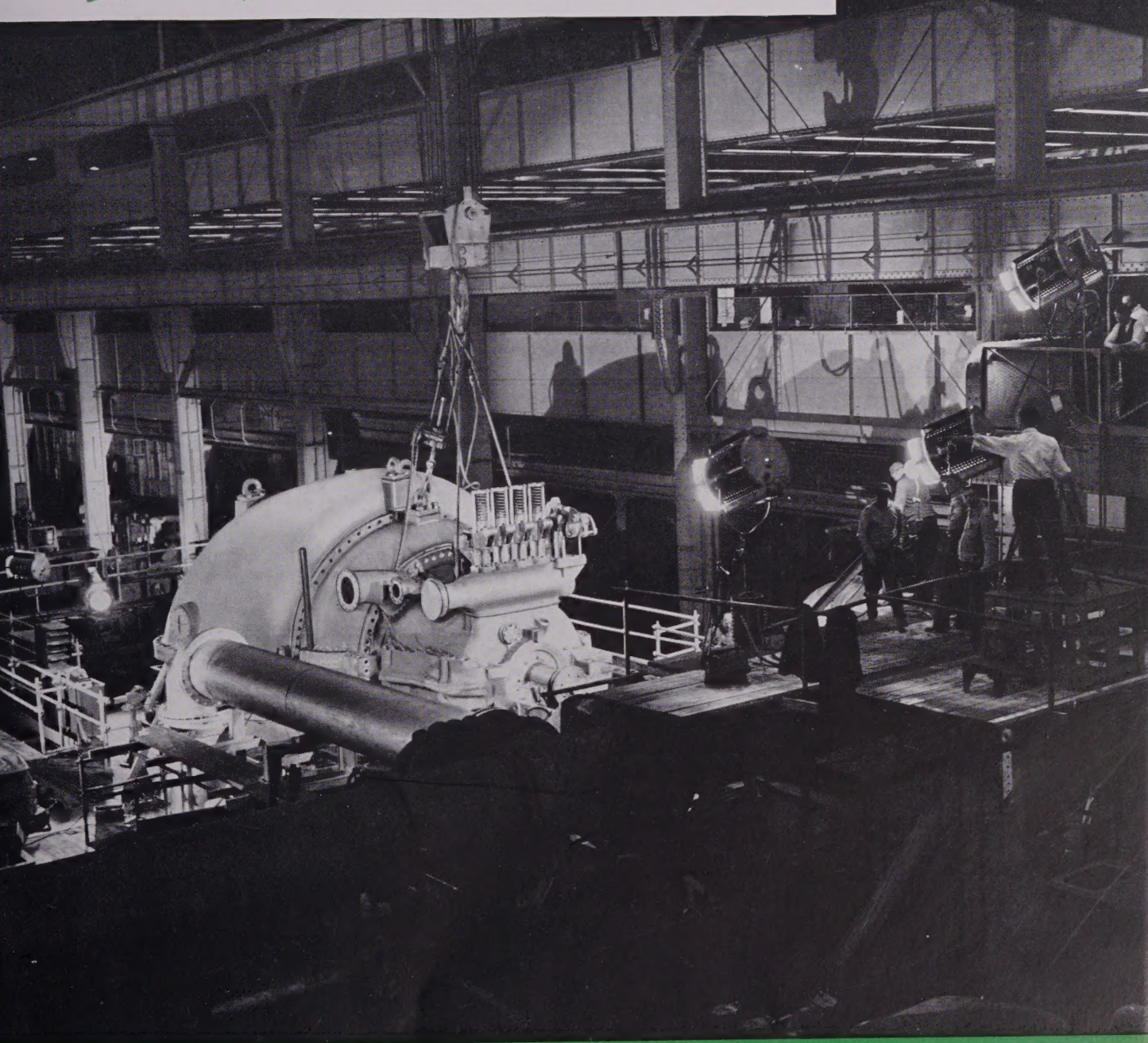
GENERAL

ELECTRIC

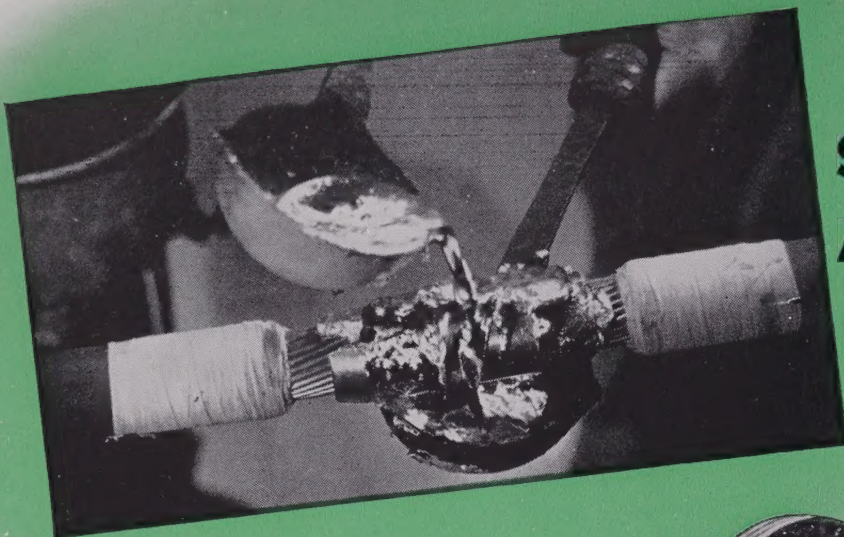
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Review

TABLE OF
CONTENTS
Page Three



May, 1948



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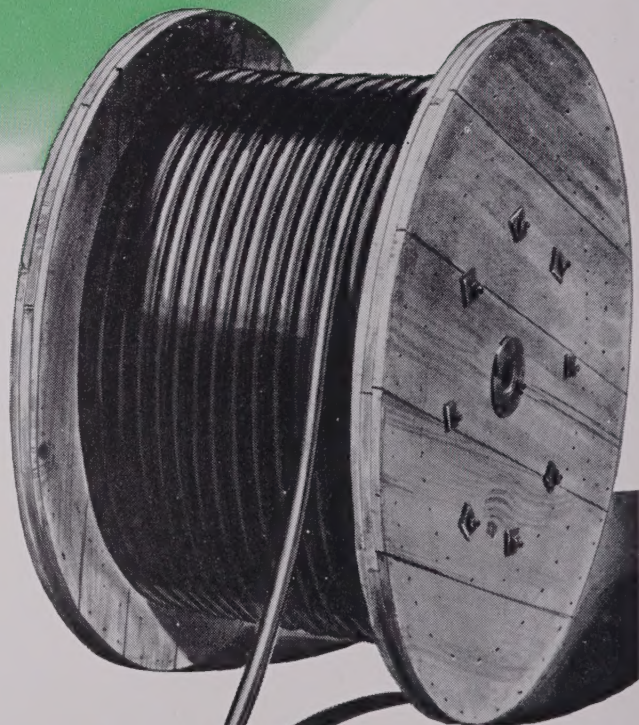
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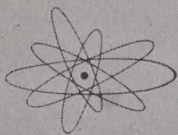


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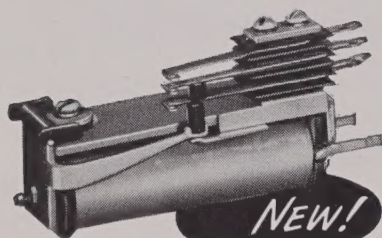


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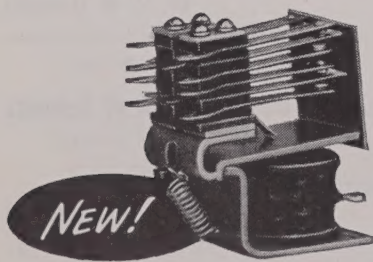
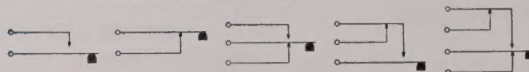
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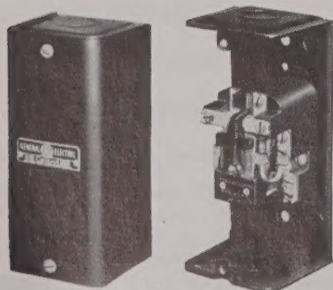
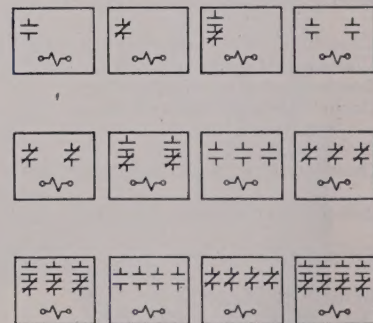
COMMUNICATIONS AND SIGNALING Designed specifically for use in industrial electronic equipment, communications and signaling equipment, this General Electric telephone-type relay has a service life measured in many millions of operations. Working from five basic contact arrangements, combinations can be stacked to satisfy intricate circuit switching requirements.

Welded-crossbar palladium contacts, new-type molded insulation and stainless steel bearings contribute to this d-c relay's longevity. Coils rated 1 to 250 volts, 0.1 to 26,000 ohms; contacts 3 amps maximum. Bulletin GEA-4859.



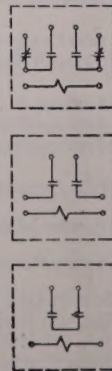
VENDING MACHINES AND DISPENSERS

Designers of coin changers, coin-operated phonographs, drink dispensers, and similar automatic devices will soon be familiar with G.E.'s new appliance relay, an inexpensive multi-contact unit. Featuring quiet operation, reliability and compactness, the CR2790G relay is available in ratings of 24 and 115 volts a-c, 24 volts d-c, 5 amps continuous. Bulletin GEA-4864.



HEAVY-DUTY GENERAL-PURPOSE Three contact arrangements—spst, dpst, and dpdt—plus four mounting arrangements give the CR2790E real versatility. Mounting arrangements available are the enclosed form shown here, open form, back-connected form for panel mounting, and a plug-in form for use in process control equipment.

Its heavy silver contacts are rated 10 amps continuous at 115/230 volts, 60 cycles; normally open contacts will make and break 45 amps, normally closed contacts 20 amps. Bulletin GEC-257 gives full details.



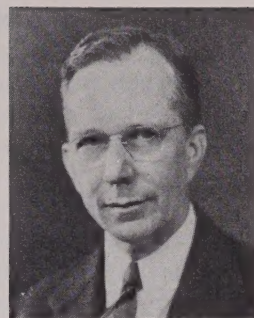
GENERAL  **ELECTRIC**

ARE NEW TYPES OF TRANSFORMER OIL NEEDED? . . . Part I

Laboratory-type tests have shown that oils assumed to be identical may differ considerably from one another. In how far the differences thus revealed are a measure of the oil's useful life is a subject requiring thoughtful consideration

By F. M. CLARK

Technical Consultant on Insulation, Apparatus Department
General Electric Company



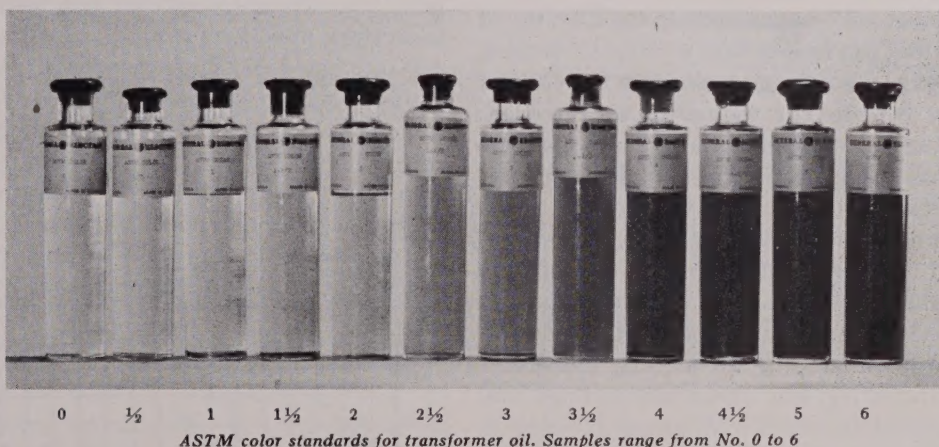
F. M. Clark

TRANSFORMER oil occupies a peculiar position in the family of dielectric materials. By those who are intimately familiar with the problems of successful transformer design and operation, transformer oil is recognized to be a highly technical material, occupying a very important position. By some, however, mineral oil is considered to be a substance which can be handled with impunity, drained from the transformer at will, blended with a miscellaneous variety of oils as long as their pour points and

sented. Different results are obtained and reported in the literature by well-recognized authorities on what might be considered the simplest of problems, the sludging value of an oil. This technical confusion is reflected in the public mind in an attitude of "they don't know what they are talking about."

Need for a Simple Test of Sludging Value

The demand is for a simple test, five or ten minutes or at least not over 24 hours long (preferably like a



viscosities are satisfactory, and in general purchased with security from any refiner with a distilling column and a sales force. This is the problem which confronts the transformer manufacturer and operator today—a problem which may be worsened tomorrow if the present trend continues.

Just what are the factors that appear to be responsible for the misunderstanding and confusion which surround the use of transformer oil today? There are many, but among the many are two or three which merit particular attention.

Nature of Mineral Oil Itself

Transformer oil is a complex chemical mixture. It changes in chemical composition from time to time, even from a single supplier. Because of this, a well-grounded and clear-cut technical story cannot be pre-

dielectric strength test), in which a nontechnical man can pour any type of transformer oil into one funnel and an answer, saying "Yes, it's good" or "No, it's bad," will come out another. This is seeking the Utopia. Oils from different sources and with different degrees of refining cannot be evaluated to the same test standards. The suitability of a newly refined oil for transformer use depends on its chemical composition, its degree of refining, and the presence or absence of materials found in small amounts, sometimes called "natural inhibitors." It would be a technical miracle if all oxidation chemistry could be reduced to a single test and a single type of reaction. The oxidation of the simplest single chemical compound is still a problem of chemical speculation; yet too often does the purchaser of a transformer or transformer oil believe that he should be given a single simple test to evaluate in a short time the expected behavior of any mineral transformer oil in commercial use over a period of 15 or 20 years

This article is so paged that, without mutilating other articles, it can be conveniently removed for separate filing by tearing out pages 9 to 14.—Ed.

The Oil-refining Situation

Every one of us uses oil in one form or another. We burn it in a furnace or we use it in an automobile. We are therefore apt to be self-appointed experts in oil. We state that this company or that makes the best oil for our automobile. If our favorite oil company can make a good motor oil, the conclusion is that it can make a good transformer oil. It can, but only if it is equipped with a technical staff qualified to differentiate between the exacting demands placed on the oil for good lubrication on the one hand and, on the other, the equally exacting demands for successful application in transformer use. These demands are not the same. The day is past when any good lubricating oil can be considered satisfactory for transformer use. Continued success in the manufacture of transformer oil, like success in other fields of manufacture, can be assured only on a basis of exact knowledge backed by years of successful manufacturing experience.

These factors sum up to a very difficult technical situation. Without a clear recognition of the importance of the product in the proper functioning of the transformer and the technical difficulties which are peculiar to the use of mineral oil as a dielectric and cooling medium in transformers, the purchaser and user of mineral transformer oil are susceptible to all sorts of testing methods and the feeling that someone is pulling the wool over their eyes. The situation can be resolved only by co-operative effort on the part of all involved: the oil refiner, the transformer manufacturer, and the transformer operator. Each in his particular realm must painstakingly seek out the truth of his position. Each must build a foundation of exact knowledge, free from speculation and bias. A mutual recognition of the exacting technical and commercial requirements presented in each of the three phases of the transformer-oil problem—its manufacture, application, and use—will go far in dispelling the misunderstandings and frequent misapplications which now appear inherent in this important phase of the electrical industry.

Transformer-oil Testing

Two classes of tests are attracting the greatest attention at the present time. The first of these is a dielectric type of test for the power factor of the transformer oil. The second is a test to evaluate the oxidation, or sludging, characteristics of the oil. There are, however, various tests used (and frequently misused) in transformer-oil specifications. Of these, only a few are outlined in the succeeding paragraphs.

Specific Gravity. The specific gravity is a characteristic which has an over-all significance in its indication of the source of crude oil and the type of oxidation product most likely to be met in the use of the oil. A low specific gravity indicates a paraffin type of oil. Such oils are characterized by a relatively high pour point, wax formation at low temperatures, and an oxidation which is accompanied by greater acidity formation than an equivalent degree of oxidation with a naphthenic type of oil,

such as is in general transformer use today. The naphthenic crudes have the higher specific gravity.

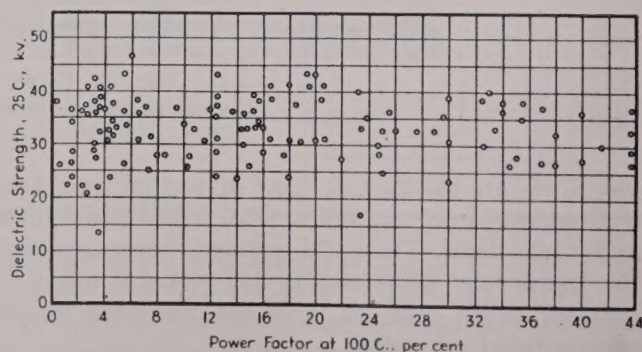
As a direct indication of usability, however, the specific-gravity value is not an important specification property.

Viscosity. Since the cooling characteristics of a transformer oil are in part due to circulation, its viscosity is a valuable engineering type of specification property. As an indication of chemical or electrical usability, however, the viscosity specification is of little value.

Pour Point. The pour point, like the viscosity of an oil, is an important engineering specification but of little value as a criterion of chemical or electrical stability.

Flash Test. The flash test is an indication of the volatility of an oil. It has but little value otherwise.

Dielectric Tests. Of the dielectric type of test, that for dielectric strength has long been accepted as of major importance. Of late, however, interest has developed in the power-factor test. It has been stated that the power-factor test is the only important dielectric test on a transformer oil, whether the oil be new or used. This statement must be reviewed impartially and with caution. The advocates of that test have in general been laboratory men, who can be classed as a group primarily interested in oil characteristics but not having to actually engage in the practice of transformer operation. The "opponents" of the power-factor test have in general been those who manufacture oil, sell transformers, or must see that transformers are kept in operation without shutdown or excessive expense for oil maintenance. In other words, the advocates in general include the development men, and the skeptics,



Power factor of mineral oil drawn from commercially operating transformers bears little relation to its dielectric strength

the practical men. This is not surprising, however, for it is to be expected that the advocates of any new type of test will be the development men while the opponents will be the practical men, who have to be convinced that the introduction of another type of test or specification is justified.

Power-factor Test

What does the power-factor test measure? It is a criterion of dielectric loss and is generally accepted as

of real value in compact apparatus where a heat balance is carefully set up by design limitations and where the major loss is of the dielectric type. Thus, in capacitors and lead-covered cable, the dielectric loss or power factor developed at rated voltage is an important criterion of the tendency toward runaway heating and the destruction of the apparatus. In such apparatus the study of oil power factor, its stability, and its relation to the power factor of the treated dielectric has been warranted. The usual cable- or capacitor-oil specifications therefore include a limitation on the oil power factor.

In a transformer, the dielectric loss in oil is not one of the important sources of heat. Limitation of oil power factor therefore does not insure against dielectric failure in service from the standpoint of heating.

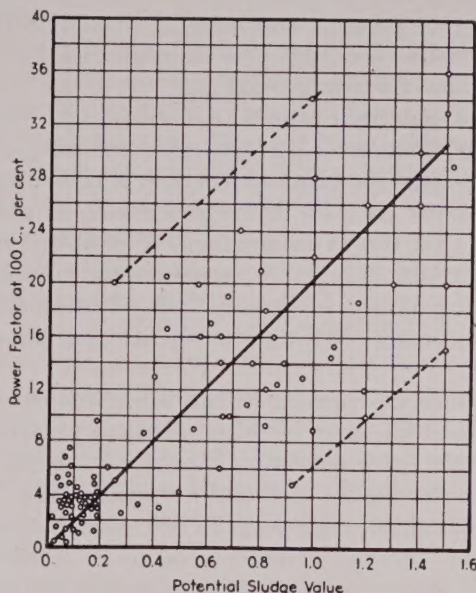
But the argument of its advocates is not so simple as that. The claim is that those factors which are important in causing transformer failure first show up in the power-factor value of the oil. Like all broad generalizations, there is both truth and falsity in such a statement.

A dry, newly refined oil should possess a power factor at 60 cycles of about 0.1 per cent at 100 C. Any contamination or oxidation of the oil tends to increase its power factor. In this sense, therefore, it is true that an increased power factor will indicate oil deterioration. However, that can be said of almost any oil test. The problem is not so much to find a test which will indicate a change in the oil from its initial state of perfection. The problem is to find a test which will serve the practical purpose of indicating dangerous and *only* dangerous change in oil condition.

The average transformer winding, even though made only from carefully selected materials, contains products which, when dissolved in oil, cause an increase in oil power factor with little if any effect on the dielectric strength or the sludge-forming properties of the oil. To set up a power-factor limitation for the oil drawn from a new transformer is going to involve far-reaching technical problems in design and manufacture. The chief result may be the academic satisfaction that the oil in the transformer is in as good power-factor condition when drawn from a new transformer as it would be if drawn from a freshly filled drum at the refinery. This is, of course, a desirable goal. But to reach that goal in an orderly way is a matter of research and development.

Now turn to the power-factor test of the oil as a criterion of its usability during transformer operation. In addition to the factors already considered as affecting the power factor of new oil, we have here the additional factors of oxidation and water pickup. The power factor of an oil increases with oxidation, but the increase obtained is determined, to a large extent, by the method of oxidation. Most laboratory oxidation tests allow the escape of water, the lighter oil acids, and other volatiles. This affects the power-factor value obtained for the oxidized oil, especially at the higher temperatures of the usual oxidation test. Furthermore,

it must be borne in mind that the type of oil oxidation and the products formed are determined by the temperature. The lower the temperature of oxidation, the more tendency there is toward acidification and the less toward sludge separation. The more acid formation



The linear relation between power factor and potential sludge value of mineral oil drawn from operating transformers is obscured by uncontrolled factors inherent in commercial transformer operation

there is, the more the power factor increases for a given amount of oxidation. It must be borne in mind also that with a different crude-oil base, different types of oxidation products are formed. For example, as already mentioned, in paraffin oils the oxidation is toward a higher acid formation for a given amount of oxygen consumed. In the face of such oil behavior, it is well to review again why there is interest in the power-factor measurement. It has been suggested as a criterion of oil condition, not from the dielectric loss itself but from the fact that it indicates the presence of those materials which give trouble either from decrease of dielectric strength or from sludging. Now, how far is this true?

Let it be assumed that water, if present, will lower the dielectric strength and increase the power factor in an orderly way. Can a power-factor specification be set up as protection against excessive and dangerous water accumulation? From the fact that oil oxidation or oil contamination will increase the power factor without any practically significant effect on the dielectric strength, it is at once obvious that the power factor of the oil cannot be set up as a selective criterion to protect against water effects.

On the other hand, neither can the power factor of the oil be established as a selective criterion of sludge formation. In the absence of all other deleterious effects, such as those by water and soluble contamination, the power factor might be related to the oxidation insofar as acid formation and the formation of other oil-soluble

oxidation products are concerned. In these, however, we do not have a primary interest. We are interested in sludge formation. But the response of the oil power-factor value to almost anything (water, solder fluxes, varnishes, oil acids, soluble paper resins, and the like) which can be taken into oil solution effectively prevents, at present, any reliable correlation between the power-factor change and the degree of the existing sludge hazard in commercial use.

But, it has been argued, a new oil with an initial power-factor value of about 0.1 per cent will give many more years of life than an oil with a power factor of 0.5 or 1.0 per cent. From the review already given it is obvious that this is an argument of doubtful validity. The expected changes in power factor commercially observed promise to outweigh any initial difference normally present in a well-refined oil from a reputable supplier.

In future discussions of the power-factor test for transformer oil—and there are going to be many such discussions—differentiation should be clearly made between the highly creditable academic goal of “no change in oil, for all change is bad” and the practical goal that “the only change in oil to be feared is one that will cause the transformer to require maintenance expense or to fail.” In the academic sense, the power-factor test may be used, as may many other tests, if we merely wish to detect oil change. To be practical, however, the test must be selective and reject those oil changes which are not actually harmful. This the power-factor test of oil does not do. The power-factor test must be looked upon at present as one of the tools of possible importance in the diagnosis of transformer and transformer-oil behavior. In the absence of a selective test, it is still necessary for us to determine the specific oil property in which we are interested by the use of a specific test. If it is the dielectric strength which is in question, it is best to run a dielectric-strength test. If it is sludge, it is best to run a test for oil sludging. This is the direct, the practical, way to evaluate oil condition. Continued research can be expected to assist in the development and understanding of the more suitable tests so greatly desired by both manufacturer and user of transformer oil.

Objectives of Sludge Test

Two types of sludge tests must be clearly recognized. Confusion results unless the objectives of each test are held clearly in mind. The first is a test to indicate what may be called the sludging propensity of an oil. In this type of test, one attempts to evaluate the tendency of a new kind of oil to form sludge in terms of the known characteristics of an oil accepted as a standard of quality on the basis of practical experience.

The second test attempts to determine, at any time during commercial use, how much of the useful life of an oil has already been consumed. This type of test is intended to tell the operator how much hazard he runs from excessive sludging if he continues the oil in transformer use.

These two types of test need not necessarily be the same. Confusion will only increase if this is not recognized.

In the first type of test, new oil, free from contamination, is being studied. In the second type of test, the study is made on a used oil containing “contamination” products which are dependent on the materials used in the construction of the transformer and on the handling of the transformer during manufacture and use. The type of oxidation product which is present in the used oil is important and is dependent on the temperature and duration of previous use as well as on the nature of the oil itself. To make the problem even more difficult, the contaminating effects in the second type of test become more important as the maximum permissible sludge value of the oil is approached in service.

The problem is comparable to that of an insurance company in its attempt to evaluate life probability. To examine an infant and from the tests predict its expected life, barring accidents, is one thing. To examine a man of middle age, to find that he gives a positive reaction to one or more types of human ills, and to predict his life with an accuracy which will eliminate the possibility of finding him dead in bed some bright morning is quite another problem. Transformer oil as it approaches its sludging point in use is like an old man. It contains all the ingredients which could start up in an uncontrolled way and end the life of the oil in a surprisingly short time. To be of value in this type of analysis a test must, in the over-all, evaluate the possibility of uncontrolled and unexpected sludging from any, or a combination of any, of the oil-soluble materials present.

Sludge Formation in New Oils

The sludging propensity of new transformer oils has been given the greatest amount of study, both in this country and abroad. In such a study the oil is oxidized under controlled laboratory conditions for a fixed period of time, or until a fixed amount of reaction product has appeared. In general, the temperature is in the range from 100 to 150 C and the time from six or eight hours up to three months. These variations, in themselves, give an indication of the confusion which exists.

It would seem axiomatic in our present state of oil knowledge that if one is testing to protect against excessive sludging, the test developed should measure the sludge formed. Nevertheless, a goodly number of investigators who are interested in sludge formation advocate measuring all sorts of property tests except sludge. They measure the oxygen consumed, the color change, the increase in acidity, the carbon dioxide evolved, the water formed, the power factor, and more recently the changing interfacial-tension value.

The difficulty in evaluating the sludging tendency of a new oil in terms of some other property is that the relation of this second property to that of actual sludging must be established. In view of the varying nature of mineral oil in use, and the varying nature of the oxidation reaction in a given oil due to differences

imposed on the oil and to the presence of uncontrolled contamination, this relationship can be established only precariously at best.

On the other hand, one cannot neglect the secondary products formed in oil during oxidation. When oil

oxidizes, there are formed peroxides, acids of varying volatility and corrosivity, water, carbon dioxide and other gases, cracked hydrocarbons, and insoluble products called sludge. Of these, corrosive acid formation if not controlled may present a hazard in itself. A properly set-up oxidation test must quantitatively evaluate all the hazards presented by the use of an oil and not limit its survey to any one type of hazard.

In this country, the American Society for Testing Materials has attempted to meet the problem of overall survey and rapid-testing requirements by establishing two different tests. In the first type of test the oil is subjected to oxidation under carefully prescribed conditions, at 120 C, in the presence of copper, for a period of time up to two weeks. This is called the development test and finds its chief use in the study of a new type of oil with no background of actual commercial use. Individual tests made on the oxidized oil include color, acid, and sludge tests. The development test gives a basic foundation for a review of the oil behavior in accordance with the facts developed. To interpret these facts safely is the job of an oil chemist with a broad background of experience in transformer oil. The problem is too complex in its possibilities to be handled by a routine analytical technician. The time necessary to form sludge, the rate of its increase with time at a fixed temperature, the rate of sludge increase with temperature at a fixed time, the susceptibility to catalytic acceleration, and the corrosivity of its oxidation products are all factors which must be considered and evaluated.

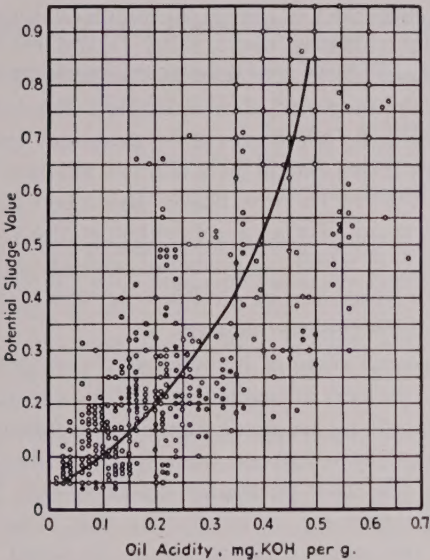
The second type of test presented by the ASTM is the short-time high-pressure, or bomb, test. This is an

oxidation test of 24 hours' duration, at 140 C, under 250 pounds oxygen pressure. The purpose of the bomb test is to check the continuity of quality of an approved oil from shipment to shipment. Standard specifications for the particular oil under consideration are established from the broader studies on which the original oil approval was based. Variation from these specified bomb-sludge values is a warning signal calling for detailed study.

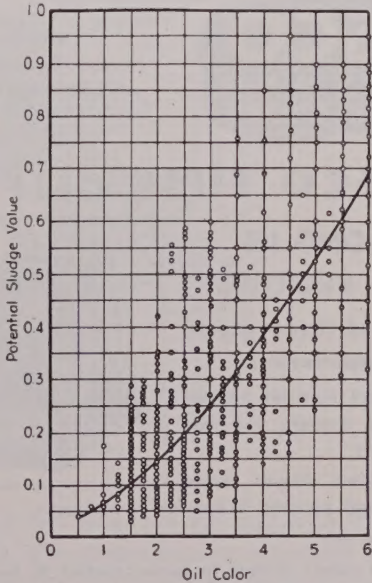
The foregoing are the two types of tests at present tentatively recognized by the ASTM; but they are not the only possible tests. Many others have been suggested, most of which have been proposed by laboratory chemists who have viewed the problem entirely from an academic chemical viewpoint.

The most strenuously advocated test at the present time is the interfacial-tension test. This is the appearance in new dress of the older, hydrophile test, which was given serious consideration ten or fifteen years ago in both the transformer- and cable-oil fields.

The interfacial-tension test measures the force necessary to pull a carefully prescribed platinum wire or ring through the interface which exists between a layer of oil and a layer of water. The conditions of test are carefully established; the test is simple and easily made. The theory behind the suggested test is that as an oil oxidizes, its interfacial-tension value decreases. The rate of decrease, or the time necessary to reach a predetermined test value, is the criterion suggested for evaluating the usability of a new oil. Because this test has received greater consideration in evaluating the usability of an oil during actual transformer service, it



Relation between potential sludge value and acidity of mineral transformer oil drawn from commercially operating transformers

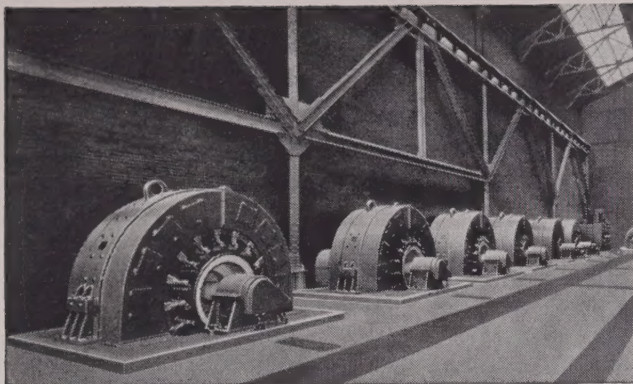


Relation between color and potential sludge value of mineral transformer oil drawn from commercially operating transformers

will be considered in greater detail in Part II of this article.

Of the remaining tests suggested for the evaluation of the sludging propensity of a new oil, the range of variation extends all the way from a purely academic

(Continued on next page)



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TRANSFORMER OIL

(Continued from preceding page)

type of test to a type in which attempts are made to duplicate practical usage. In one type of test, for example, copper catalyst, iron catalyst, and cotton twine are present. The test covers therefore the effect of catalyst, the effect of the oil on the mechanical strength of cellulose, sludging, and acidity. In the test for oxygen absorption, little if any reference is given to other factors arising as a result of oil oxidation. Since oil darkens when oxidized, some so-called practical men merely place the oil in a bottle on a window sill and record the time it requires to turn black. But even this type of test may be of just as much value as the most highly technical test which neglects to evaluate all potential sources of trouble and confines its conclusion to one primary or secondary change.

The present state of knowledge of the oxidation and sludging reaction in insulating oil tends to support the conclusion of the practical engineer when he insists that the present function of laboratory evaluation is to eliminate the most obviously defective oils. Oils which appear satisfactory on laboratory test must now, and perhaps for some time to come, be tried out on a limited commercial scale before being adopted for general transformer use. Caution in this respect will pay dividends in the form of trouble-free transformer operation.

(To be concluded)

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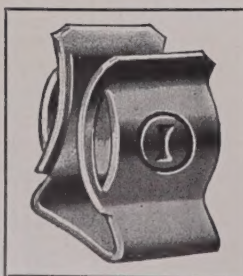
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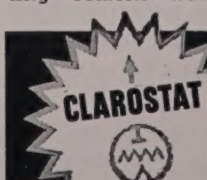


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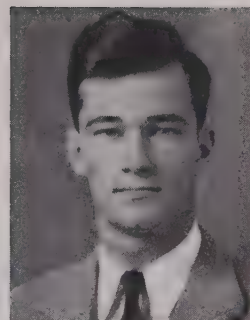
TACHOMETER TESTING FACILITIES INCREASED ELECTRONICALLY

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The system in operation and the advantages that were realized

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General Electric Company



Harvey H. Chamberlain

AT THE outbreak of the war, equipment was in existence for high-precision production calibration of aircraft tachometer indicators.⁽¹⁾ As production increased, however, it became apparent that increased testing facilities would be required. At the same time, it was also apparent that it would be extremely costly and would require a large amount of floor area to provide this increase in test facilities by installing additional equipment similar to that already in use. The electronic means by which the use of the existing calibrating system was multiplied to extend it to the new requirements is the subject of this article.

and adjusting the strength of the drag magnets until the instrument indicates 3000 rpm. After this has been accomplished, the instrument is checked up and down its scale in small increments of speed to determine whether the indication is within the prescribed limits.

The Existing System

The existing calibration equipment was composed of a d-c motor driving a number of standard tachometer generators through suitable gears to provide indicated speeds of 500, 600, 800, 1000 rpm, and so on in steps of 200 rpm up to 4400 rpm. The frequency range

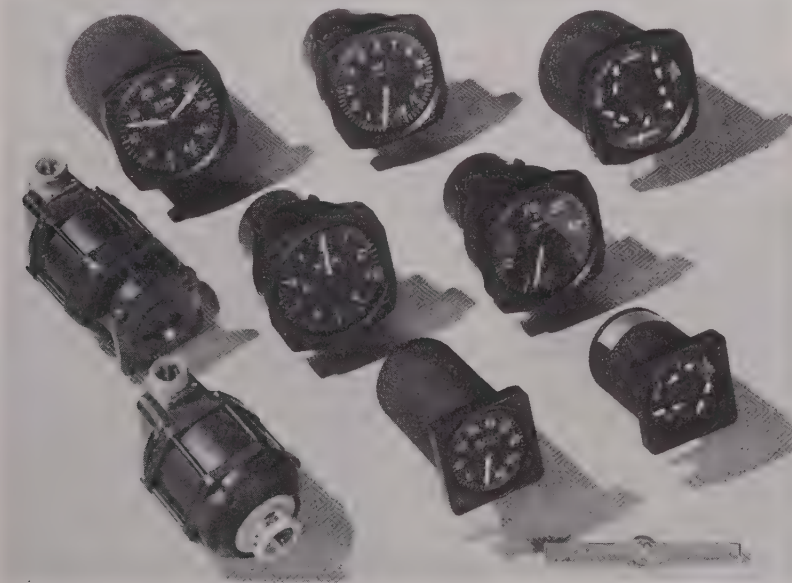


Fig. 1. Generators and indicators comprised in a tachometer system

Briefly, the tachometer to be calibrated is used in a system consisting of a three-phase synchronous generator mechanically coupled to the aircraft engine and connected electrically to a three-phase synchronous motor in the indicator. This motor drives a conventional magnet-and-drag-disk assembly against restraining springs, thus providing a pointer indication proportional to speed. Fig. 1 shows tachometer components of this type.

Calibration of the indicator is accomplished by operating it at a frequency equivalent to 3000 rpm

represented by these speeds was from $8\frac{1}{3}$ cycles to $73\frac{1}{3}$ cycles. The driving motor was held at the proper speed to within 0.01 per cent by means of a tuning-fork oscillator and amplifier, the output of which was used to control the field of the motor. The output of the generators was fed to the testing area to control boxes of the type shown in Fig. 2. Two generators were available for each of the 21 test frequencies; and since each generator was capable of running two tachometer indicators, four stands were available.

This article is so pagged that, without mutilating other articles, it can be conveniently removed for separate filing by tearing out pages 15 to 18.—Ed.

(1) "Precision Testing of Electric Tachometers," by M. A. Princi, *A.I.E.E. Trans.*, vol 64, 1945, pp. 504-508.

Augmenting Test Facilities Electronically

Since the idea of adding equipment similar to that already installed did not appear practical, electronic means were considered for furnishing the additional test stations. By amplifying the existing generator



Fig. 2. Tachometer test stand showing old-type control box

signals electronically, it was believed that many advantages could be realized:

- (1). Any number of stations could be added without increasing the power demand on the existing generators
- (2). No additional rotating machinery would be required
- (3). Considerable saving in money and space could be realized
- (4). Required components would be more available
- (5). Construction time could be reduced.

These advantages definitely favored some electronic means of providing the necessary stations and led to establishing the following basic requirements:

- (1). Accurately reproduced voltage and frequency with a minimum distortion of wave form
- (2). Remotely controlled test stands because of space limitations in the testing area
- (3). Simple and fast operation of test stands
- (4). Minimum maintenance of equipment.

Fundamentally, the solution consisted of picking off two of the three phases of the desired generator by means of a rotary stepping switch, amplifying these two phases independently, and combining them in open delta to drive the tachometer indicators under test. A block diagram of the system is shown in Fig. 3.

The System in Operation

The voltages from 21 generators are distributed to the various amplifiers and connected to a rotary stepping switch. From the simplified schematic diagram shown in Fig. 4, it can be seen that the frequency selected by this switch is fed into the feedback network and gain control. The 6N7 phase inverter drives two 6L6's in class A, which are in turn resistance-coupled to the grid circuit of the power amplifier. The power amplifier is somewhat unusual and was designed to provide not only a large power output while using low-voltage receiving-type tubes, but also to provide a low value of internal impedance to maintain good regulation.

The twenty 2A3's are operated in push-pull parallel class A with self-bias, thus providing a conservative output of 40 va. A dual tachometer operating at 4400 rpm requires approximately 20 va; and since two amplifiers are required for one operating station, this results in a large reserve of power. In practice four or five tubes can fail without causing an objectionable lowering of output. Further improvement in regulation, together with insensitivity to changes in line voltage, is obtained by feeding a portion of the output voltage back to the input through the feedback network.

The output transformers are of a special design, using a core of half Mumetal and half silicon steel to provide proper operation at the low frequencies encountered.

Two such amplifiers, controlled as a unit from one operating station, are required to operate one single- or dual-tachometer indicator.

The control box at an operating station is shown in Fig. 5. It contains advance and reset push buttons, a

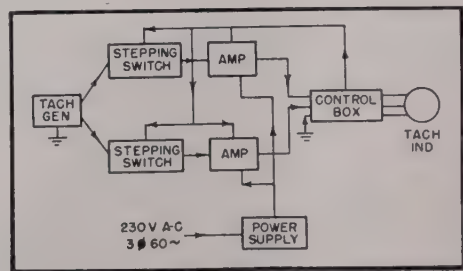


Fig. 3. Block diagram of calibrating equipment

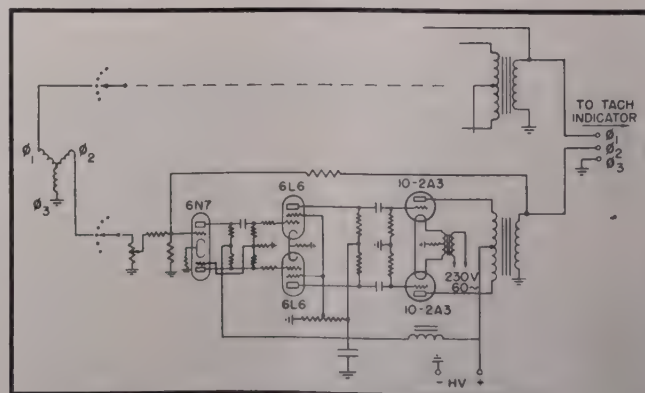


Fig. 4. Simplified schematic diagram of amplifier

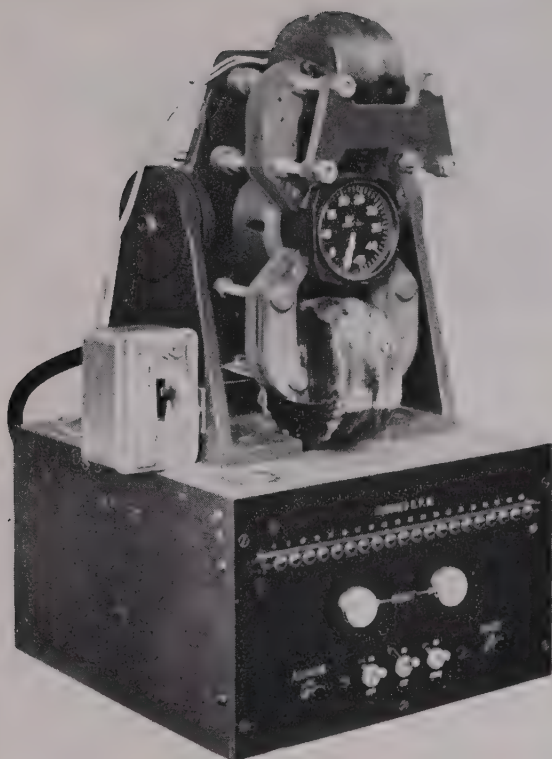


Fig. 5. Tachometer test stand showing new-type control box

toggle switch for turning on the amplifiers it controls, switches for energizing either single or dual tachometers, pilot lights to indicate when the stepping switches are reset, and a row of pilot lights to indicate the particular speed in use. Mounted on top of the control box is the

holding fixture with dual "knockdown" coils for setting either the right- or left-element drag magnets to their proper strength. Inside the control box are two relays and the stepping switch. An eight-wire cable connects the control box with its respective amplifier.

D-c power for the amplifiers is provided by a single power supply, which consists of a 3-phase full-wave system using type GL414 mercury-vapor thyratrons and which is capable of supplying 360 volts at 40 amp. Since the total amplifier drain is about 20 amp, a large factor of safety for the power supply is provided. No filter is used because the ripple amplitude from this type rectifier is small, and the ripple frequency of 360 cycles is well above any response of the tachometers. Protective overcurrent relays resettable from the testing area are used with each amplifier.

The amplifying stations, d-c power supply, and protective relays are shown in Fig. 6. Each of these cabinets contains two amplifiers and is, therefore, associated with one control box. Fig. 7 is a view of one of the amplifying stations showing the chassis and interconnecting cables.

For Calibrating Purposes

The operation of a station for calibration purposes is simplicity itself. After inserting and connecting a tachometer, the operator makes sure that both reset pilot lights are on by pressing the reset button. This insures that both the frequency-selecting stepping switches in the amplifiers and the speed-indicating stepping switch in the control box have been returned to their zero position. Pressing the advance button now gives a frequency equivalent to an indicated speed of



Fig. 6. Calibration stations showing amplifiers and power supply

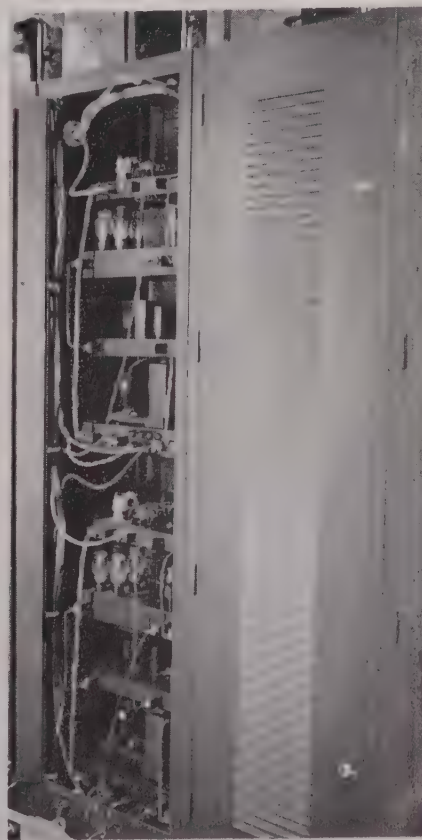


Fig. 7. Rear view of amplifying equipment used for calibrating aircraft tachometer indicators



Fig. 8. Test positions in the calibrating room utilizing electronically augmented equipment for production testing of tachometer units

3000 rpm. At this point the tachometer is brought into calibration by knocking down the drag magnets. By depressing the advance button successively, indicated speeds of 4400, 4000, 3000, 2000, 1000, and 500 rpm will be given in that order. For calibration purposes, these are the only required speeds, but for checking purposes, the full complement in 200-rpm steps is necessary, both ascending and descending. These are available by continuing to depress the advance button. The stepping switches can be returned to the zero position at any time by depressing the reset button.

Fig. 8 shows the calibrating room in use. The variable transformers under the bench supply 60-cycle voltage to the knockdown coils, and the switches on the left-hand side of the holding fixture connect the output of this variable transformer to either the upper or lower knockdown coil, depending on which element is being calibrated. For a single-element indicator, either coil can be used; but, for a dual-element indicator, the upper

coil is used for calibrating the left element, and the lower coil is used for the right element.

Advantages Realized

The equipment described was used for over two years, operating the greater part of this time for 15 hours a day, 6 days a week, with very little maintenance. Actually, the production rate did not require continuous use of all stations; thus one or two standby units were always available. Consequently, loss of operating time was practically nil even when trouble did occur, since the operator could change to a standby station, or the particular section causing trouble could be replaced with a section from an idle station.

The electronic solution to the problem of increasing existing calibrating facilities for tachometers proved to be entirely satisfactory and was one of the important contributions to a very rapid expansion in tachometer production necessitated by the wartime demand.

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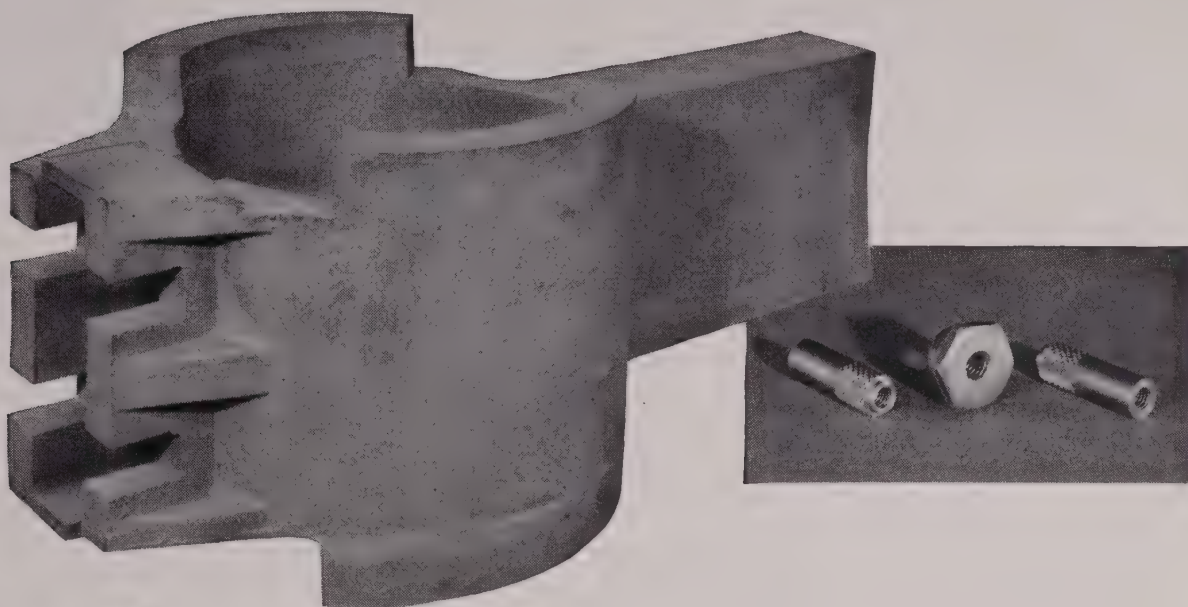
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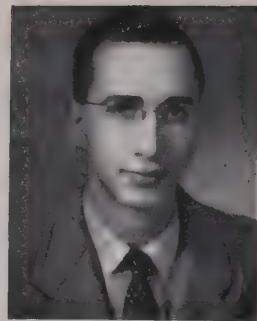
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100,000-VOLT PULSES MEASURED WITH CAPACITANCE VOLTAGE DIVIDER

Specially designed vacuum capacitor maintains accurate voltage ratios for high-voltage pulses as short as one-tenth of a microsecond and provides for laboratory-precision study of wave shapes and transient phenomena

By STEPHEN C. CLARK, JR.
General Engineering and Consulting Laboratory
General Electric Company



Stephen C. Clark, Jr.

WITH the application of high-powered short-pulse techniques to radar and pulse-modulation communication systems there has developed an increased need for an instrument to measure and view high-voltage pulses in the order of $1\ \mu\text{s}$.

Calibrated oscilloscopes were already available for measuring and viewing low-voltage pulses. Hence the addition of a voltage divider capable of accurate reproduction of short high-voltage pulses at low-voltage levels would readily provide the required instrument. Because the resistance dividers which had previously been used in high-voltage power-system transient study were too bulky and could not maintain the accurate voltage ratios required for these high frequencies or very short pulses, attention was directed toward the design of a capacitance voltage divider.

Requirements

The voltage divider to be designed should be free from phase and amplitude distortion, should have an accurate fixed voltage ratio at all frequencies and voltage levels, and should produce no appreciable load on the circuit being measured. For such applications as viewing and measuring the pulsed output of microwave relay transmitters installed at remote locations, the divider should provide laboratory precision for field measurements; accuracy should be unaffected by

changes of temperature or humidity. The divider should also be compact, lightweight, and portable.

The capacitance voltage divider developed to meet these requirements is capable of measuring and viewing pulses as short as $0.1\ \mu\text{s}$ with peak voltages to 100,000 volts. The instrument accurately reproduces at low-voltage levels high-voltage impulses having frequency components to 10 megacycles.

Three voltage ratios (500:1, 100:1, and 10:1) were made available to enable input signals up to 100,000 volts peak to be measured on a 200-volt instrument. Continuous waves up to 500 kilocycles may be applied. Voltage ratios are calibrated accurately within five per cent and will change less than one per cent over a wide ambient temperature range up to $65\ \text{C}$. The voltage divider occupies less than 2000 cu in. and weighs less than 20 lb, including the transit case.

The divider applies the fundamental theory that two pure capacitances connected in series divide an alternating or pulsating voltage in inverse proportion to the values of capacitance. The input requires a low capacitance to prevent loading of the circuit to be measured.

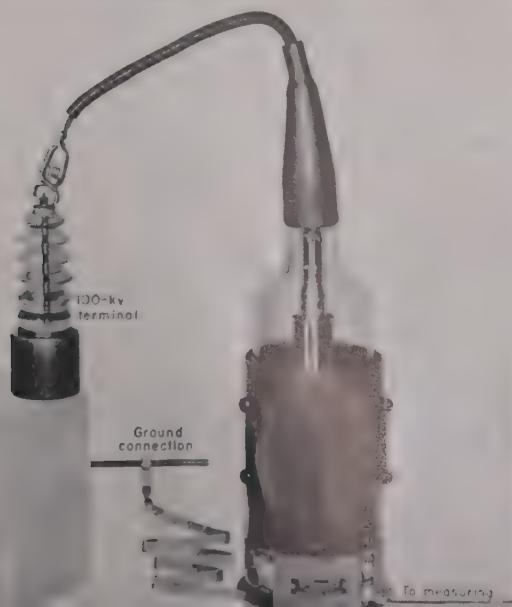
Development

The major problem was the development of a compact, high-voltage low-capacitance capacitor free from inaccuracies due to leakage or corona. Available dielectrics having high voltage-breakdown strengths were found to have dielectric constants which varied with frequency and also tended to be hygroscopic. Glass lead-through insulators were also tried, utilizing the capacitance between center conductor and mounting flanges. By sealing the base of the glass insulator into a container of pressurized sulphur hexafluoride gas, the flashover voltage of the insulator was increased. However, the use of glass insulators was not satisfactory for this application because corona within the air bubbles in the glass caused capacitance changes at high voltages.

Vacuum Capacitor

To obtain a corona-free capacitor, a special high-voltage vacuum capacitor employing coaxial construction was developed. Concentric cylinders were sealed in the glass envelope of the type used for kenotron high-voltage rectifiers. This not only provided a con-

Fig. 1. The capacitance voltage divider used for 100-kv measurements. Cylinders of the vacuum capacitor are enclosed in the glass envelope; auxiliary capacitors are mounted in the base of the unit



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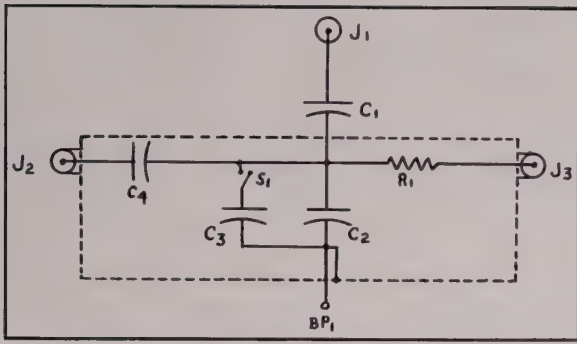


Fig. 2. Circuit diagram of the divider, showing the arrangement of the vacuum capacitor C_1 . Input jack J_1 is for 100 kv; J_2 for 2 kv

stant capacitance for all voltages but was self-healing when overvoltaged. No evidence of cold-cathode emission from the capacitor cylinders was detected at voltages up to 125 kv. As incorporated in the design, the vacuum capacitor is mounted on a cast aluminum base and protected by a plastic guard (Fig. 1).

Circuit Operation

The circuit shown in Fig. 2 employs a fixed mica capacitor C_2 which provides the low-voltage capacitance series-connected to the vacuum capacitor C_1 . A ratio selector switch S_1 inserts an additional capacitance C_3 and permits choice of voltage ratios of 100:1 and 500:1. For voltages below 2 kv, the two fixed mica capacitors C_4 and C_2 provide a ratio of 10:1; C_2 , C_3 , and C_4 are installed in the base of the divider.

The output impedance of the divider is matched to a coaxial cable which connects to the measuring instrument. The capacitance of the cable and the input capacitance of the measuring instrument are a part of the voltage divider; therefore, changes in length or type of cable or terminating capacitance affect the calibration of the voltage ratio and require the application of simple correction factors. Fig. 3 shows these correction factors for various types and lengths of cable; the largest correction is less than ten per cent.

The frequency limits for distortionless reproduction of waveshape by the divider are determined by the length of cable and the impedance of the measuring instrument. For high-impedance instruments the division ratios are maintained accurately within two per cent for frequencies from 1000 cycles to 10 megacycles, with no detectable waveshape distortion. In addition, the divider has been

used successfully as a potential transformer at 60 cycles, with a high-impedance vacuum-tube voltmeter as the measuring instrument.

Calibration

Calibration of the divider presented a problem, for no accurate standard was available for comparison. At first, the capacitance voltage divider was connected in parallel with a resistance divider to the output of a high-voltage surge generator. An oscilloscope was connected in turn to the output of each divider. Photographs recorded the surge pulses as they appeared on the oscilloscope. However, these photographs lacked sufficient accuracy for calibration.

The voltage ratios were successfully checked in several ways after having first been adjusted to one per cent by capacitance measurements from a 60-cycle Schering bridge. Comparative measurement of input and output voltages at 60 cycles gave ratios constant within three per cent for all voltages up to 125 kv. Tests with high-voltage 2- μ s pulses gave ratios agreeing within three per cent with the 60-cycle measurements. Accuracy of reproduction of pulses is shown in Fig. 4.

The capacitance voltage divider as developed is an accurate and reliable instrument addition to the field of high-voltage measurements. Its compactness and portability will make possible field studies of corona and dielectric voltage breakdown under pulsed or transient conditions and should further provide a laboratory instrument for the study of radio-frequency waveshapes, short-duration high-power pulses, and high-voltage switching transients.

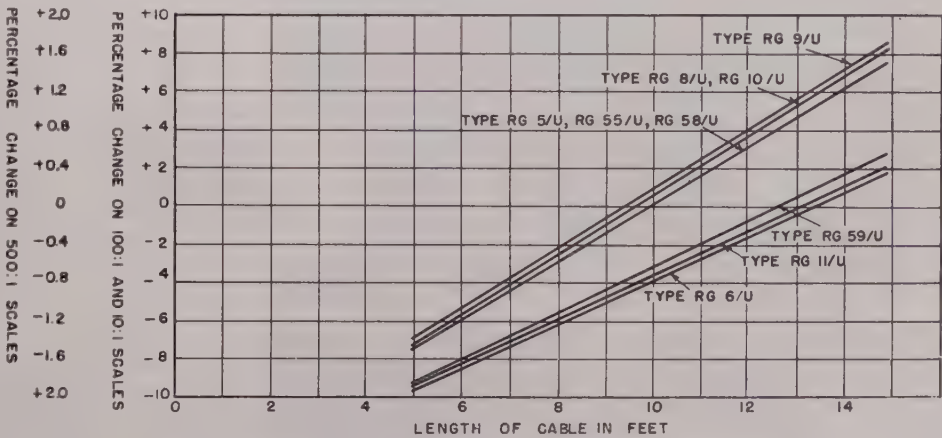


Fig. 3. Correction factors for various types and lengths of coaxial cable used with the voltage divider

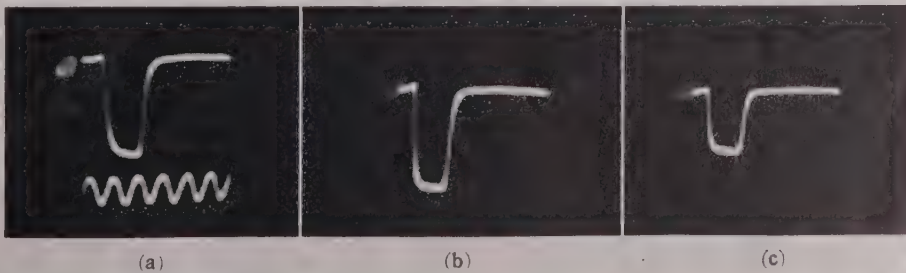


Fig. 4. Waveshapes showing accuracy of reproduction: (a) 2- μ s 100-volt peak input pulse to 100 kv section with 1-mc timing wave; (b) 2- μ s 1-volt peak output pulse for 100:1 ratio; (c) 2- μ s 0.2-volt pulse for 500:1 ratio

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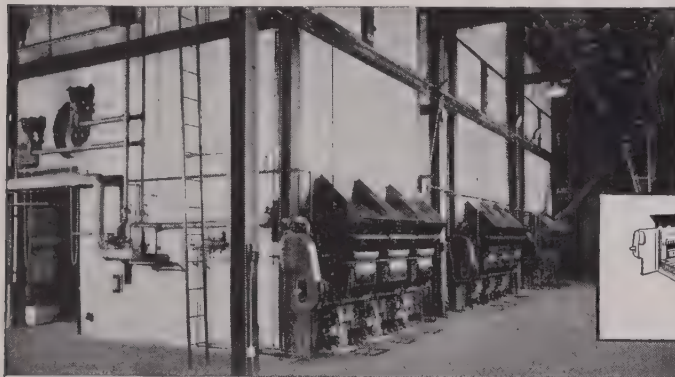
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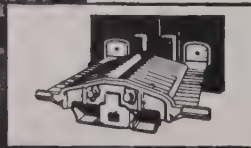
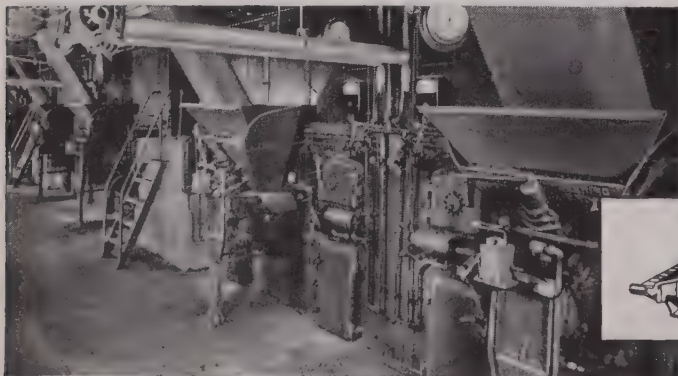
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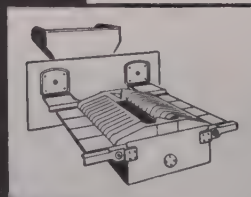
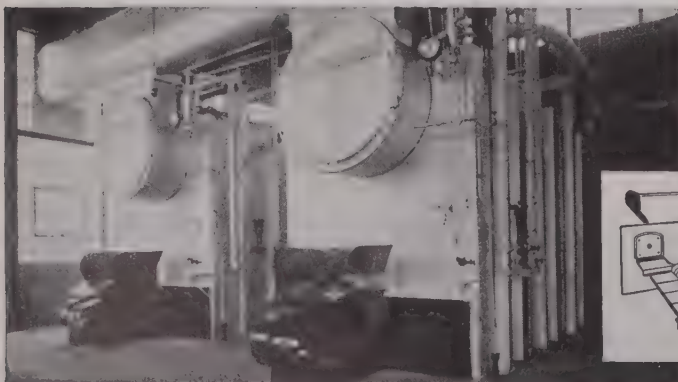
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SPREADER STOKER — Approximate Application Range — 150 boiler hp to largest units suitable for stoker firing. A simple, rugged stoker designed to burn a wider variety of fuels than any other type of mechanical firing. Hopper, feeding and distributing mechanism, variable-speed drive and motor are combined in a compact unit. Rotating spreader blades feed coal into the furnace in crisscrossing streams which assure uniform distribution. Fines are burned in suspension and the rest of the coal is burned on a grate — either dumping or continuous discharge type. Grate surface is zoned for regulating air admission and to facilitate cleaning.



TYPE E STOKER — Approximate Application Range — 150 to 600 boiler hp. A single-retort underfeed stoker designed to burn a wide variety of bituminous coals. Ram feed is supplemented by a reciprocating sliding bottom. Grate surface consists of hollow, air-cooled grate bars, alternately fixed and moving, to condition the fuel bed and assure its steady movement toward the dump trays. Air supply under zoned control with provision for introducing air over the fire. Steam, electric or hydraulic drive.



SKELLY STOKER — Approximate Application Range — 20 to 200 boiler hp. A compact, self-contained unit offering all the advantages of underfeed firing. Moving grate bars assure lateral distribution of fuel and maintain a clean porous fire. Cantilever dump grates of non-avalanching type simplify ash removal. Integral forced-draft fan, with inlet control, permits positive regulation of air-coal ratio. Sixteen rates of coal feed through variable-speed transmission. Automatic control is standard equipment. Timken bearing equipped. Alemite lubrication throughout.

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COSMIC RAYS Part II

About one milligram of primary particles from cosmic space falls on the earth in one year with a power of about one million kilowatts, spent chiefly in ionizing the atmosphere

By DR. C. W. HEWLETT

Consulting Physicist, West Lynn and River Works Laboratories
General Electric Company

IN THE earliest work on cosmic rays the intensity of ionization in closed vessels and the absorptibility of the ionizing rays were the principal subjects of study. The intensity of the cosmic rays was inferred from the rate at which ions were produced in a closed vessel containing an insulated charged electrode connected to an electrometer. The rate of ion production was calculated from the rate at which the electrode potential changed because of saturation ion current in the closed vessel. From changes in the ion current when the vessel was surrounded by layers of absorbing substance, the absorptibility of the cosmic rays was inferred. The information to be derived from such measurements is rather limited, and these were soon supplemented by more powerful and discerning tools.

Track Studies with Cloud Chambers

For many purposes, the most instructive method of studying individual rays is to observe the tracks made by them in a Wilson expansion chamber, or cloud chamber. **Fig. 3** will make clear the design and operation of this device. The air inside the chamber is saturated with water vapor, and the enclosed space may be expanded by jerking back the piston. The operation depends upon the fact that if there are no ions present when dust-free air saturated with water vapor is expanded quickly and thereby cooled, a considerable expansion is necessary to cause precipitation of the water vapor; whereas, if ions are present a somewhat smaller expansion causes a water droplet to condense about each ion. In this way the path of an ionizing ray can be made visible as a line of water droplets. The rays to be observed are allowed to pass through the chamber just before expansion. After the tracks have been observed the piston is pushed back, restoring the original pressure, and the droplets re-evaporate. An electric field is applied momentarily to clear the space of ions, and the chamber is then ready for another operation. The tracks are illuminated by a strong beam of light and are either observed visually or photographed through the glass top or sides of the chamber. By using two cameras *C*, **Fig. 3**, pointing at different angles, stereoscopic pictures of the tracks can be made. The whole apparatus is often arranged to operate automatically, expansions being produced at intervals of 10 to 30 sec.

Sometimes the cloud chamber is used in combination with a Geiger or Müller counter, the two being so arranged that a ray passing through the cloud chamber must also pass through the counter. The operation of the counter is then arranged to trigger the expansion mechanism of the cloud chamber. This achieves economy in cloud-chamber observations, particularly when photographic technique is used, since the cloud chamber operates only when there is something inside it to be observed.

A strong magnetic field is frequently maintained in the cloud-chamber space so that the charged rays will be bent into circular arcs. From the magnitude of the curvature, the approximate value of the energy of the ray can be inferred. The direction of the curvature for

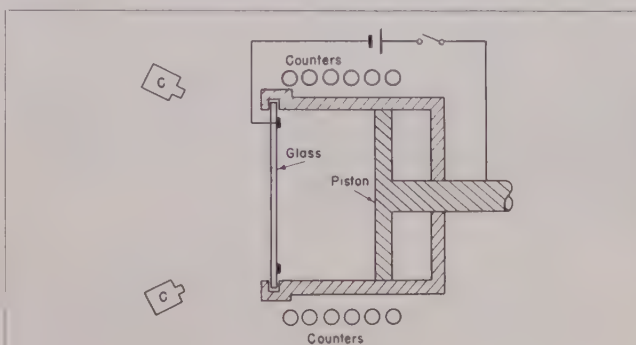


Fig. 3. Outline drawing of a Wilson cloud chamber

The face of the piston is usually coated with water-soaked gelatine so the enclosed space will become saturated with water vapor in a short time. Several preliminary operations of the piston serve to condense water vapor on residual dust particles which are allowed to settle out, leaving the cylinder volume filled with dust-free air. After the expansion, which causes condensed water droplets to outline the ray path strewn with ions, the piston is again pushed forward, re-evaporating the droplets and freeing the ions. The latter are then sucked out of the space by closing a switch in the electric circuit shown, and the chamber is ready for another operation. The counters shown above and below the chamber are used to trigger off the actuating mechanism when an ionizing ray passes through the counters and the cloud chamber. The cameras, *C*, on the left take stereoscopic pictures of the ray tracks in the cloud chamber.

a given direction of motion relative to the direction of the magnetic field is determined by the sign of the charge of the particle. For a specific charge, the number of droplets per unit length of path is approximately determined by the mass of the particle. **Fig. 4** is a reproduction of a cloud-chamber photograph showing several kinds of ray tracks. Beta-rays produce thin and slender tracks with sudden changes in direction of motion produced by atomic encounters. Alpha-rays produce very dense tracks with 50,000 to 100,000 droplets per centimeter of path; because of their great

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mass, they are deflected scarcely at all during atomic encounters. Protons produce tracks of a density intermediate between those of alpha-rays and beta-rays, while meson rays produce tracks of density intermediate between those of proton rays and beta-rays. It is thus clear that by experience and insight one may learn much about the nature of ionizing rays in a study of the ion paths produced by them in cloud chambers. Frequently barriers composed of sheets of lead are placed across the cloud-chamber space so that the rays will either be stopped by them or pass through them. This gives further information about the energies of the rays. If a given ray passes through a barrier so that its track shows on both sides of the barrier, the differ-

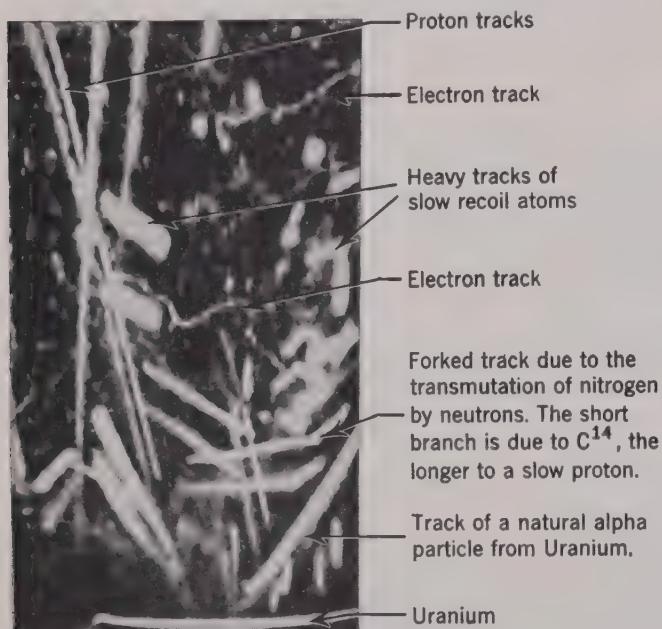


Fig. 4. Reproduction of a cloud-chamber photograph showing the effects of a neutron source on an air-and-water-vapor mixture. The track of a natural alpha particle from uranium is also visible. (Courtesy Prof. I. A. Gettings, Massachusetts Institute of Technology. See Pollard and Davidson: *Applied Nuclear Physics*, Plate I, p. 11, John Wiley and Sons, Inc., New York.)

ence in curvature (produced by a superposed magnetic field perpendicular to the direction of motion of the ray) on the two sides discloses on which side of the barrier the energy was greater, and thereby divulges the direction of motion. Such technique and ingenious interpretation was used by Anderson in the discovery of the positive electron. Fig. 5 is a picture of a small shower of positive and negative beta-rays originating in the wall of the cloud chamber. In Fig. 6, a similar picture, the shower exhibits multiplication in passing through a lead plate. Fig. 7 shows a dense shower which is greatly multiplied in passing through the lead plate. Most of the tracks shown in the figures are beta-ray tracks. Fig. 8 shows a shower passing obliquely through the cloud chamber. Fig. 9 shows a meson penetrating two layers of lead and being stopped by a third layer. In Fig. 10 a fast meson is seen passing through three lead plates. Fig. 11 is from a stereoscopic picture of a proton ray produced in a nuclear disintegration. Fig. 12 is a similar picture showing four of the



Fig. 5. A positive and negative electron pair presumably produced by a high-energy photon and deflected in opposite directions by a magnetic field applied perpendicular to the plane of the photograph. This pair is part of a small shower of positive and negative beta-rays that are visible in the original photo. (Courtesy Prof. J. C. Street, Harvard University. See Pollard and Davidson: *Applied Nuclear Physics*, Plate I, p. 11, John Wiley and Sons, Inc., New York. See also *Rev. Sci. Inst.*, 7, 347, (1936).)

particle rays resulting from the disintegration of a nitrogen nucleus. Such pictures as those shown in Fig. 12 are sometimes referred to as "stars."

Ray Detection by Means of Electric Counters

Electric counters consist of two electrode tubes filled with an easily ionized gas. One of the electrodes is either a fine point or ball (Geiger counter) or a fine wire (Geiger-Müller counter); the other is a surrounding cylindrical electrode. A potential difference not quite high enough to produce corona discharge is established between these two electrodes, and when an ionizing ray passes through the space between them the ions so produced are drawn into the electrodes. Those falling into the small electrode produce ioniza-



Fig. 6. Cascade showers generated in the upper of two lead plates (each 1 cm thick). The low-energy particles in the shower are absorbed in the second lead plate. (Courtesy Prof. Marcel Schein, Chicago University; photo by F. Allen.)



Fig. 7. A shower of very high energy striking the cloud chamber, some of the high-energy particles traversing both lead plates (each plate 1 cm thick). Multiplication is visible below the first plate, and the direction of the particles in the shower is clearly indicated. (Courtesy Prof. Marcel Schein, Chicago University; photo by F. Allen.)

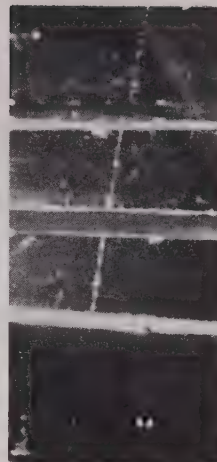


Fig. 10. The track of a fast meson as it passes through all three lead plates and appears in all four compartments of the cloud chamber. (Courtesy Prof. R. D. Sard, Washington University.)

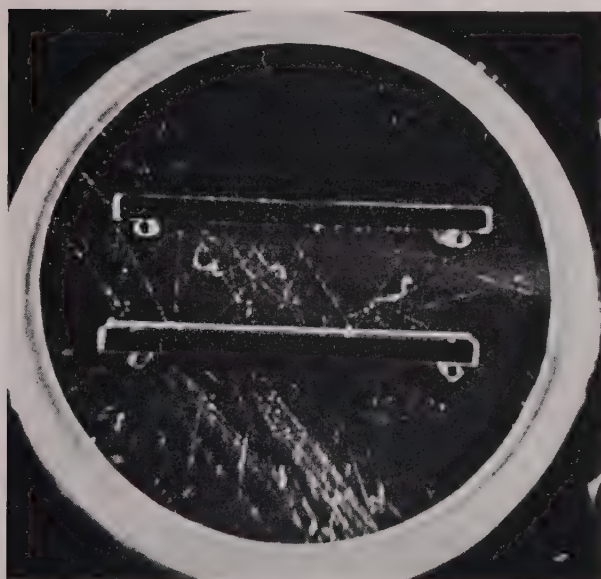


Fig. 8. A shower, produced outside the cloud chamber, passes obliquely through the chamber. The lead plates are 1 cm thick. (Courtesy Prof. Marcel Schein, Chicago University; photo by F. Allen.)

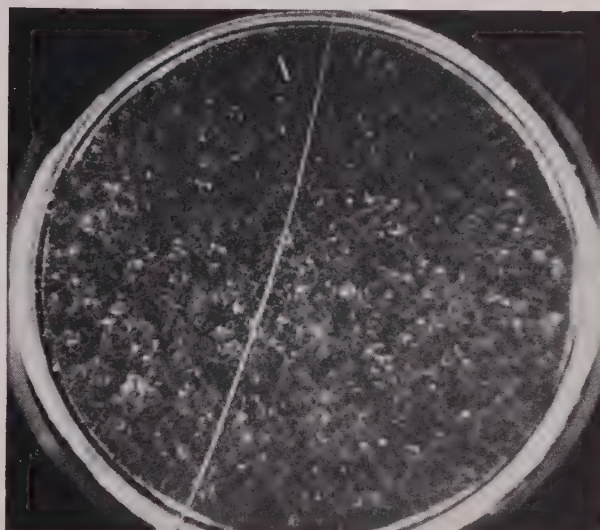


Fig. 11. A proton moving across the chamber in the general direction of the x-ray beam of the 100-Mev betatron. The cloud chamber and target were separated by a distance of 25 ft; the diameter of the chamber is 12 in.; the magnetic field perpendicular to the plane of the picture was 2650 gauss. From the curvature of the ray, its energy is calculated to be 9 Mev. Energy-transfer considerations indicate that this proton ray must have originated in a nuclear disintegration in the walls of the chamber. The background is formed by many overlapping electron tracks of all directions and energies. (Courtesy Dr. E. E. Charlton and Dr. George C. Baldwin, Research Laboratory, General Electric Co., Schenectady (N. Y.). See Baldwin and Klaiber, *Phys. Rev.*, 70, 259, (1946).)



Fig. 9. One of the rare cases in which the meson is photographed near the end of its range. There are three lead plates in the cloud chamber; from top to bottom, the thicknesses are 4 gm/cm², 11 gm/cm², and 43 gm/cm². The meson track is of normal density in the top compartment, perhaps of somewhat greater density in the second, and of definitely greater density in the third. The particle is absorbed in the thick bottom plate and does not appear in the bottom compartment. (Courtesy Prof. R. D. Sard, Washington Univ. See Pollard and Davidson: *Applied Nuclear Physics*, Plate I, p. 11, John Wiley and Sons, Inc., New York.)



Fig. 12. Disintegration of a nitrogen nucleus caused by a photon from the 100-Mev betatron. The heaviest track is an alpha-ray and the two others proton rays. The disintegration is presumably described as: $\gamma N^{14} + h\nu \rightarrow {}^4_2\text{He}^1 + 2{}_1^1\text{H}^1 + {}^7_3\text{Li}^7$. The recoiling residual nucleus leaves the illuminated region a short distance from the site of the disintegration. Momentum is not conserved with the visible tracks. (Courtesy Dr. E. E. Charlton and Dr. George C. Baldwin, Research Laboratory, General Electric Co., Schenectady (N. Y.). See Baldwin and Klaiber, *Phys. Rev.*, 70, 259, (1946).)

tion by collision in the intense field near the electrode, causing a rush of current through the tube; this current is promptly quenched when the original ions have disappeared. The rush of current produces a momentary sharp potential change on the electrode, and this potential change can be applied to an amplifier circuit which may then perform a variety of functions, such as the operation of a mechanical counter, the triggering of other electric circuits, etc. **Fig. 13** shows several counter arrangements used to study various aspects of cosmic-ray phenomena. The upper-left section shows an arrangement by Bothe and Kolhorster in which they measured the absorption coefficient of cosmic rays when passing through gold. The circles *C* represent two tubular counters between which is inserted a block of gold. The counters were surrounded by plates of iron and lead to shield off all local radiations so that only the highly penetrating cosmic-ray particles could enter the counters. Particles coming from directly above, if sufficiently penetrating, could pass through both counters. Each counter registered its counts on a photographic film. The apparatus was placed near the roof of the building. With the block of gold (4.1 cm thick) removed, the simultaneous counts of the two counters were about 180 per hour, and this number decreased by 25 per cent when the gold absorber was put in place. Assuming that the numbers of simultaneous counts *N* and *N*₀ with and without the gold absorber, respectively, were related by the equation $N = N_0 e^{-\mu x}$ where μ is a constant and *x* is the thickness of the gold absorber, Bothe and Kolhorster found that $\frac{\mu}{\rho} = 3.5 \times 10^{-3}$ where ρ is the density of gold. This is a characteristic order of magnitude for the absorption coefficient of cosmic rays at sea level.

Since that early experiment, registration on photographic film has been replaced by electronic circuits so devised that only coincident registrations of two or more counters will be recorded. The upper-right section of **Fig. 13** shows an arrangement of three counters with lead absorbers placed between them. This arrangement reduces still further the disturbing effects of stray and scattered radiations, and at the same time restricts still further the angular distribution of incoming cosmic rays that can cause coincident registrations in all three counters. Such an arrangement is called a "counter telescope" and was used by Rossi to measure the mass-absorption coefficient of cosmic rays in various thicknesses of lead. He found that for the first 10 cm of lead the mass-absorption coefficient was 1.8×10^{-3} , and in the next 15 cm was 0.5×10^{-3} , and in the last 76 cm was 0.55×10^{-3} . From these results it is evident that the cosmic rays include ionizing rays of very great penetrating power. The lower-left section of **Fig. 13** shows an arrangement of three counters in which showers of at least two particles can be registered by the simultaneous excitation of three counters. The function of the absorber *A* is to shield the counters from local radiations and to provide dense matter in which showers may be produced with reasonable fre-

quency. Reasonably frequent showers have been observed in this kind of arrangement with all three counters separated by distances of the order of a few tens of meters. The lower-right section of **Fig. 13** shows an arrangement in which the absorption coefficient of the shower particles can be measured. The number of coincidences with and without the presence of the absorber *B* furnishes the data from which the absorption coefficient can be calculated. It is found that most of the shower particles are absorbed by a few centimeters of lead. This is in accord with the theory of showers or cascades, already outlined.

Besides ionization chambers, cloud chambers, and counter-tube arrangements, there are other methods for studying the behavior and nature of cosmic rays that have been used on occasion, such as the magnetic

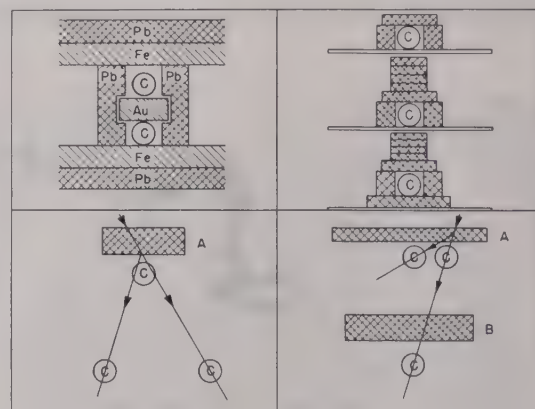


Fig. 13. Four counter arrangements for the study of cosmic-ray phenomena

At upper left are shown two counters, *C*, arranged vertically with a block of absorbing material between them. Thick blocks of metal around the counters prevent the entrance of secondary and scattered radiation; only the most penetrating cosmic radiation from above can pass through the counters. By counting the coincidences of registration with and without the absorbing block (gold in the illustration) the absorption coefficient for the rays in that material can be calculated.

At upper right is a "counter telescope." Only rays entering through a small angular region will pass through all three counters, and again the interposition of more or less absorbing material between the counters makes it possible to measure the penetrating power of the rays. The whole arrangement can be tipped for exploring different parts of the sky.

The lower-left section shows a shower-detecting arrangement of counters. Absorber *A* shields the upper counter from extraneous secondary radiation and also serves as a place where a shower may originate. Each of the three counters may register simultaneously; this is probably caused by a shower of ionizing particles originating in *A* in the vicinity of the top counter and produced by a penetrating cosmic-ray particle.

At lower right is a counter arrangement that can be used to study the penetrating power of shower particles. The number per hour of coincidences of the three counters, with and without the absorber *B*, makes it possible to calculate the absorption coefficient of these shower rays in the material composing *B*.

spectrograph, photographic plates, and fluorescent screens. Their applicability, however, is rather limited. As the more powerful tools came into use, and their potentialities were realized, there was a great acceleration of investigations; and at the present time there is an enormous literature both theoretical and experimental on the subject of cosmic rays.

Effect of the Magnetic Field of the Earth

The magnetic aspect of the earth as it is presented to an incoming charged particle can be represented to a close approximation by a magnetic dipole situated at the center of the earth. In spite of the intrinsic

weakness of the magnetic field of the earth, its effect on a charged particle coming in from a great distance will still be large because of the extent of the field. **Fig. 14** is a schematic representation of the approximate distribution of the earth's magnetic field in a plane passing through the magnetic north and south poles. Since a magnetic field exerts on a charged particle

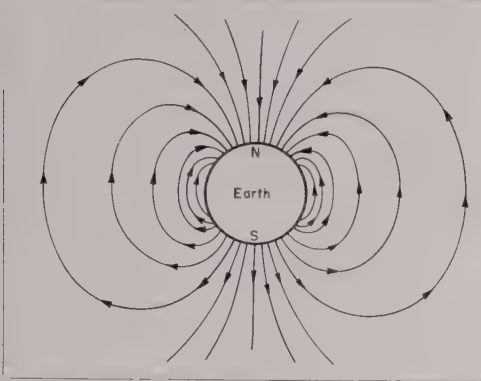


Fig. 14. An idealized schematic representation of the nature of the magnetic field of the earth exterior to its surface

The representation is for a plane passing through the magnetic axis. To a considerable degree of approximation this field may be considered as that due to a magnetic dipole situated near the center of the earth. The magnetic north pole of the earth is situated in the antarctic region and conversely for the magnetic south pole of the earth.

charged. For electrons, the lower limiting energy is 10.2 billion electron volts (10.2 Bev) and the upper limiting energy is 59.4 Bev. The corresponding values for protons are 9.3 and 58.5 Bev, respectively. It is noticeable that at such high energies the difference in the rest mass between electron and proton makes very little difference in the deflection of the particles in a magnetic field. This is because at such high energies the masses of electrons and protons are nearly equal. As was mentioned, these quantitative statements are for particles approaching the earth in the magnetic equatorial plane. It is upon such particles that the effect of the magnetic field of the earth is greatest.

(which is moving so as to cut the lines of the field) a force always at right angles to the direction of motion of the particle, it follows at once that the earth's magnetic field cannot change the energies of these particles. Therefore all charged rays that reach the earth from outer space must do so with the full complement of energy that they carried before nearing the earth. It is also evident that charged rays directed initially toward either magnetic pole of the earth will reach the earth without deflection by the magnetic field. The effect of the magnetic field on the path of a charged ray can be calculated, whatever the initial direction of motion may be. The effect will be given in terms of the charge, mass, and velocity of the particle, and of the known magnetic moment of the dipole representing the magnetic field of the earth. In the general case, the calculation is very difficult, but it has been carried out.

For rays approaching in the magnetic equatorial plane the calculation is simpler, and **Fig. 15** shows typical paths for such particles. These paths are for rays of various energies all coming in from the same direction. The diagram shows that many particles, even though originally directed toward the earth, will be bent back and returned to space so that they cannot reach the earth. There is a certain minimum energy that the particle must have in order to just graze the earth horizontally, and there is another somewhat higher energy above which particles will reach the earth at all angles. At the lower limiting energy, the particles will come in from the west if they are positively charged and from the east if they are negatively

charged. Results of the analysis of the more general case may be summarized as follows: If it is assumed that the charged cosmic-ray particles of a given energy approach the earth equally from all directions, then for very high energies they remain equally distributed in direction in spite of their deflection by the magnetic field. Critical energies, such as those described for particles arriving in the equatorial plane, occur in all cases, but these critical energies decrease with increasing magnetic latitude. At the magnetic poles both of these critical energies are zero. At a given point on the surface of the earth, particles with energy less than the lower critical energy value (proper to the latitude of the point) cannot arrive at all. As the energy rises above this lower critical value, particles begin to arrive from the west if the particles are positive and from the

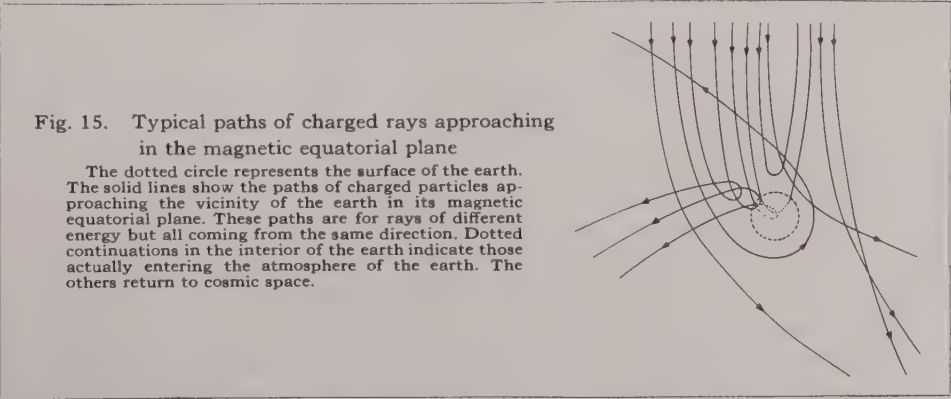


Fig. 15. Typical paths of charged rays approaching in the magnetic equatorial plane

The dotted circle represents the surface of the earth. The solid lines show the paths of charged particles approaching the vicinity of the earth in its magnetic equatorial plane. These paths are for rays of different energy but all coming from the same direction. Dotted continuations in the interior of the earth indicate those actually entering the atmosphere of the earth. The others return to cosmic space.

east if they are negative. As the energy rises still more, the particles come from a larger and larger part of the sky until, when the second critical energy value is reached, the particles arrive with equal intensity from all directions, just as if the magnetic field were absent. No further change in the arriving particles then occurs with further increase of energy.

With regard to the distribution of the magnetic deflection effect over the surface of the earth, **Fig. 16**

shows graphically the results of the calculations. The theoretical results may be summarized as follows: Charged particles with energy less than a certain lower limit (10.2 Bev for electrons, 9.3 Bev for protons) cannot reach the earth on the magnetic equator, although they may reach it elsewhere. Particles with

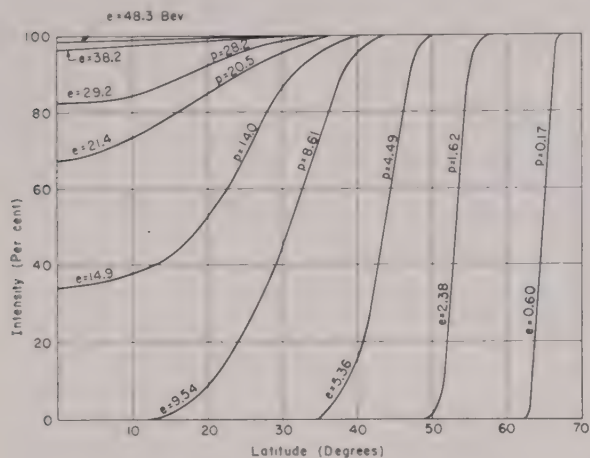


Fig. 16. Relative intensity of electrons and protons of various energies that can enter the atmosphere at different magnetic latitudes

This relative intensity is expressed as a percentage of the intensity in cosmic space.

Consider electrons of energy 14.9 billion electron volts (Bev) or protons of 14.0 Bev passing through cosmic space equally in all directions. At the equator these particles will enter the atmosphere with about 33 per cent of the intensity with which they enter at 40 deg latitude, and this latter intensity is the intensity of this radiation component in free space. Again, electrons of 9.54 Bev or protons of 8.61 Bev will just begin to enter the atmosphere on the horizon at 10 deg latitude; they will reach 50 per cent of their maximum intensity, coming from a large portion of the sky, at 32 deg latitude; and they will come in equally from all directions at full intensity at 44 deg latitude.

energy exceeding a second critical value (59.4 Bev for electrons, 58.5 Bev for protons) arrive at all parts of the earth from all directions with full intensity, just as if the magnetic field were absent. As we move north or south from the equator, the minimum energy for arrival and the minimum energy for full intensity both decrease. Above 60 deg magnetic latitude, even electrons and protons of 2 Bev will arrive from all directions without diminution by the magnetic field.

Principal Facts about Cosmic Rays

(1). Cosmic rays have great penetrating power and their energies appear to range from 5 to 1000 Bev. They can be detected in deep mines, at a depth of 750 ft of water, and through 75 ft of lead. Fig. 17 shows a scale of absorption as calculated by ionization measurements below the surface of Lake Constance. In the early days the great penetrating power of the rays led to the supposition that the primary cosmic rays were photons.

(2). Ionization due to cosmic rays increases with altitude at all latitudes, but the increase is least at low latitudes. It increases with altitude to approximately 57,000 ft, and at higher altitudes again decreases. This is shown graphically in Fig. 18, from 0.5 to 1.0 meters of water below the top of the atmosphere. Until recent rocket flights the highest altitude at which measurements were made was 72,000 ft.

(3). The intensity of the ionization of the atmosphere at sea level varies with latitude, being smallest at the magnetic equator, increasing with increase of latitude until approximately 40 deg magnetic latitude

is reached, and then remaining nearly constant for higher latitudes. This may be seen in Fig. 18, where the curves for 51-deg and 60-deg latitude are seen to coalesce at a considerable depth below the top of the atmosphere. Fig. 19 shows more directly the nature of the variation of intensity of ionization with latitude at sea level. These observational data are seen to be in general agreement with the theoretical predictions which can be made from observations of the effect of the magnetic field of the earth on incoming charged particles, and make it quite certain that a large part at least, of the primary cosmic rays are charged particles moving with great speed.

(4). There is a small azimuth effect at sea level, the intensity of the rays coming from the west being slightly greater than that of rays from the east. According to the resumé of the magnetic theory that has been given, this indicates that the primary cosmic rays are positively charged particles.

(5). Directional measurements of the number and energy of cosmic-ray particles by means of counter telescopes have shown that cosmic rays do not come from any preferred cosmic direction.

The intensity of ionization in the atmosphere is slightly greater at noon than at midnight. This may be due to the cosmic rays' being slightly focussed by the electrical, magnetic, and gravitational fields of the sun. The correlation of the activity of the auroral and austral lights with sun-spot activity makes it almost certain that these lights are mainly caused by low-energy beta-rays projected from sun spots into the terrestrial polar regions.

(6). There are frequent showers or bursts of secondary radiation components, apparently originating from single cosmic rays, particularly when the rays pass through dense slabs of matter. These showers are observed in ionization-chamber studies, in cloud-chamber studies where may be seen the tracks of the

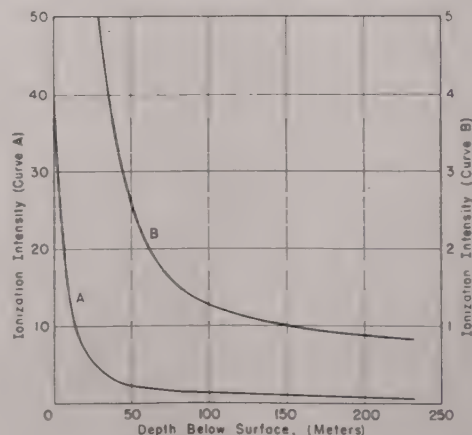


Fig. 17. A graph of absorption of cosmic rays below the surface of Lake Constance

The intensity of ionization in arbitrary units is plotted vertically and the depth below the surface is plotted horizontally. The ordinates on the left are for curve A, and those on the right for curve B, which is a reproduction of that portion of A at depths greater than about 30 meters.

shower particles of widely varying numbers of rays diverging from approximately the same point in the absorbing slab, and in the operation of multiple-counter-tube arrangements. The showers that have been depicted in the chamber photographs are thought to be the result of the multiplicative, or cascade, process which is originated by high-energy protons and beta-rays in a manner already described.

Attempts to Explain Observed Data

At the surface of the earth the intensity of ionization of the atmosphere is minimum at the equator and increases with increasing latitude until 40-deg magnetic latitude is reached, after which no further increase occurs. The theoretical treatment of the effect of the magnetic field of the earth leads one to expect a continuous increase with latitude until the magnetic pole is reached. At the time the latitude effect was discovered, it was widely proposed that the primary cosmic rays were high-energy beta-rays. On this assumption, the cessation of the increase of ionization at 40 deg magnetic latitude was explained by supposing that the minimum energy for entry at that latitude is just sufficient to enable the rays containing that amount of energy to reach the bottom of the atmosphere. Although the number of rays entering the atmosphere might be expected to increase on the further journey to the pole, this increment of rays of lesser energy would not have enough energy to penetrate the full depth of the atmosphere and so would not be observable at sea level.

According to the foregoing consideration, all the rays entering the atmosphere at the equator should penetrate the whole atmosphere, and no increase would be expected in the intensity of ionization with altitude. As has been pointed out, however, this is not true. It was therefore suggested that the primary cosmic rays knocked out of the atoms of the atmosphere high-energy beta-rays to an extent that increases with the energies of the primaries themselves, so that high in the atmosphere—where the primaries have not yet lost

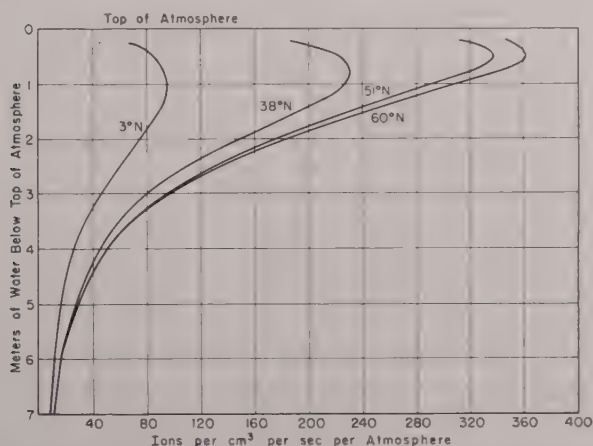


Fig. 18. Variation of cosmic-ray ionization with altitude

The level in the atmosphere above which the total air is equivalent to a depth of 1 meter of water is marked 1 on the ordinate scale. The total depth of the atmosphere is equivalent to approximately 10.34 meters of water; the data in the above figure do not extend to the bottom of the atmosphere. Near the bottom the ionization due to cosmic rays increases until 40 deg latitude is reached, but becomes nearly constant for higher latitudes. At high altitudes, however, ionization varies rapidly with latitude.

much energy by ionization—more secondaries are ejected than at lower altitudes. This hypothesis provided for the observed increase of ionization intensity with altitude at the equator. The quantum theory of atomic structure predicted that very kind of phenomenon for beta-rays; and the wave mechanics pre-

dicted the cascade process, already described, for the high-energy photons and beta-rays. Those ideas would account for the observed increase of ionization up to a certain height and thereafter a decrease; and so, for a time, it was regarded as highly probable that the primary cosmic rays were largely high-speed beta-rays. The

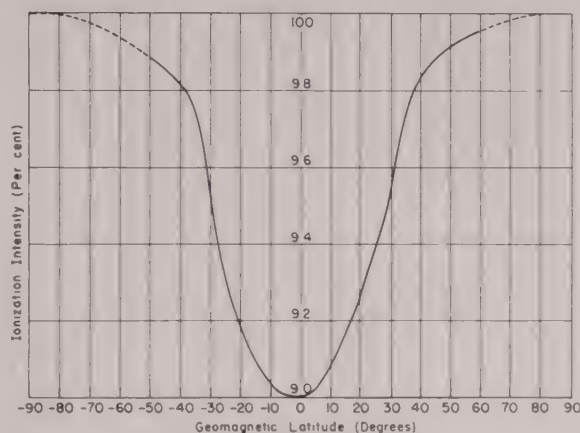


Fig. 19. The variation of ionization at sea level as a function of geomagnetic latitude

This plot is adjusted on the assumption that the intensity at the equator is 90 per cent of the full intensity at the magnetic poles.

more recent views of cosmic-ray phenomena still retain the cascade process exhibited by high-energy photons and beta-rays, although it has been found necessary to modify the conception as to the nature of the actual primary particles which first enter the atmosphere.

Quantitative calculations of the energy loss by ionization suffered by high-speed primary beta-rays and by their progeny indicate that neither such primaries nor their progeny could reach the bottom of the atmosphere in sufficient number to be consistent with the measured ionization intensities near the top and at the bottom of the atmosphere; low- and medium-energy beta-rays would lose all their energy by ionization before going more than a small fraction of the distance, while very-high-energy beta-rays would die in a short distance by producing secondary beta-rays and photons, resulting in the cascade process, and the cascades would also die out in a relatively short distance. Moreover, the azimuth effect at sea level indicates that the primaries are positively charged particles. If the primaries were protons, it would be expected (from the known ionizing properties of these particles) that near the ends of their ranges they would for a short distance produce intense ionization. But at the bottom of the atmosphere (where this phenomenon might be looked for) nothing of the kind is to be found; this fact eliminated the possibility that the cosmic rays observed at sea level and in mines are protons. Specifically, the primaries must be preponderantly positively charged particles, but the proton is too massive to be a candidate for the cosmic rays observed at sea level. Which, then, of the known nuclear particles could be forming these cosmic rays? Not the neutrons, because they have no charge and produce no ordinary ionization.

It was then discovered in cloud-chamber and mass-spectrometer investigations that the penetrating cosmic rays at sea level, and lower, were fast-moving particles having about 180 times the mass of the electron or one-tenth the mass of the proton. Such particles are the mesons, previously described. The theory of wave mechanics teaches that a particle having a mass of this size (with the energies under consideration) is relieved of the responsibility of becoming the progenitor of a long line of offspring—that is, the originator of a cascade—which is the fate of a high-energy electron. The theory also teaches that with a mass as small as this (one-tenth the mass of the proton), the particle does not have to produce tremendous bursts of ionization near the end of its range as does a proton losing energy by ordinary ionization. The meson loses energy preponderantly by ordinary ionization until it has been slowed down considerably, at which time it vanishes, giving birth to a single high-energy beta-ray and, supposedly, to a neutrino.

When those facts were first discovered, it was natural to suppose that mesons constituted the primary cosmic radiation coming to earth from cosmic space. Against this point of view, however, there arose three difficulties:

- (1). If the energy of the mesons be measured at sea level and a calculation is made back to the top of the atmosphere, allowing for the loss of energy by ionization on the way, it is found that before losing any of their energy by ionization many of them had insufficient energy to penetrate the magnetic field of the earth. Therefore, at least some of the mesons must be produced in the atmosphere itself.

- (2). The life of mesons, as determined by comparative absorption measurements in water and air, is from 1 to 2 microseconds for slow mesons, and not greater than 1 to 2 seconds for mesons that could penetrate the magnetic field of the earth. Therefore, all mesons coming to the earth from cosmic space would have died in traversing a distance equal to the radius of the solar system, even if moving at the speed of light.

- (3). The azimuth effect leads to the conclusion that practically all the incoming charged cosmic particles, which are responsible for what is observed at sea level, are positively charged. Magnetic deviation observations in cloud chambers, however, show that mesons observed at sea level are practically equally distributed with respect to positive and negative signs of charge.

The three foregoing considerations render it highly improbable that mesons reach the vicinity of the earth from cosmic space; therefore they must be produced inside the atmosphere. This means that the mesons themselves cannot be primary rays but must have been produced by another primary which is itself positively charged. It must then be supposed that this primary ray, coming into the atmosphere, somehow creates mesons which journey onward but which can very well

have been created in approximately equal numbers, positive and negative. These mesons apparently possess the power to pass through considerable thicknesses of matter because most of the energy loss is due to ordinary ionization, in which each ionizing act results in a loss of only a few electron volts of energy. Only occasionally they lose a much larger amount in a single act by knocking out of an atom a highly energetic beta-ray that in itself produces more ionization and may start a cascade, which expends all the energy by ionization in a relatively short distance.

As already stated, when the meson dies it gives rise to a beta-ray and, presumably, a neutrino. Considering only the energy lost by ordinary ionization, a meson having an energy of 20 Bev could penetrate the atmosphere and a further depth of 200 meters of water.

Although it is not known just how the positively charged primaries give rise to mesons, a plausible and, at present, acceptable hypothesis is that a massive positively charged primary, upon colliding with an atmospheric atom, splits into a number of mesons nearly equally divided between positive and negative electronic charges. Each meson has the speed of the primary parent particle, $1/N$ of the mass, and consequently $1/N$ of the energy of the primary particle. From the measured distribution of the meson energies determined at sea level and up to 4 km altitude, it is possible by a somewhat involved calculation to determine the mass which the heavy parent particle would have to possess in order to penetrate the magnetic field of the earth. The mass so calculated comes out to be the *mass of the proton*. It may then be concluded that mesons observed at altitudes not exceeding 4 km are produced by primary particles that are protons.

It might be supposed that when the proton explodes, the component mesons will fly off equally in all directions. This would be true if the frame of reference were moving with the proton; but from a frame of reference fixed in the earth the events appear differently. Because of the very high speed of the proton the velocity directions of the resulting mesons, when observed in the frame of reference fixed in the earth, would lie closely grouped about the velocity direction of the parent proton. That is, as observed from the earth, the directions of motion of the individual mesons would be closely grouped about the original direction of motion of the incoming proton. Much the same thing happens in the case of the occasional energetic beta-rays knocked out of atoms by mesons.

At great altitudes (near the top of the atmosphere) it has been observed that many of the secondary ionizing rays are moving at wide angles to the vertical, a large percentage of them even moving horizontally. When the matter is considered quantitatively, it is found that the observed horizontal component is too large to be explained by the fact that primaries, having more than a certain amount of energy, come in equal numbers from all portions of the sky.

Let it now be supposed that singly charged particles, even more massive than the proton, are moving with

the velocity necessary to penetrate the magnetic field of the earth. Because of the greater mass, the required velocity would be less than that of protons. The resulting meson velocity would also be less and, by the same reasoning as given earlier, the meson velocity direction, with respect to the earth, would be more widely distributed about the velocity direction of the parent particle than would that of the proton. In fact, if these heavy primaries are assumed to be singly charged helium atoms, the calculated distribution of the velocities of beta-rays born as their grandchildren (the mesons being the parents), at an altitude corresponding to 0.1 atmosphere still above, would be in harmony with the observed facts. Mesons with such small energies, corresponding to the velocity appropriate to singly charged helium atoms, would have average lives of only about two microseconds. They would die before they had traveled more than 300 meters, and their offspring, the beta-rays, would be born within that distance of the birthplace of the mesons.

We may therefore form the following picture as to the general nature of cosmic rays: The incoming primary particles from cosmic space are very fast protons and singly charged helium atoms. These particles are deflected by the magnetic field of the earth in such a way that those moving in the magnetic equatorial plane, and having less than a certain energy, are unable to enter the atmosphere of the earth; while particles traveling along the axis of the earth can enter the atmosphere at all energies. The high-energy protons, upon collision with atmospheric atoms, break up and give rise to high-energy mesons, which are observed at all altitudes down to sea level and below. The energetic beta-ray offspring of these mesons are also present at all altitudes. The equally energetic but more slowly moving singly charged helium ions give rise, through less energetic mesons, to correspondingly less energetic beta-rays, which are confined to the upper regions of the atmosphere; a large number of these move in directions inclined at wide angles to the vertical. As soon as such a beta-ray is formed, it proceeds to propagate its species in the cascade process already described, and in so doing fills the upper air with photons and ions.

From that picture it may be predicted that the total radiation will reach a maximum intensity in the higher

regions of the atmosphere, after which it will diminish because the outermost regions contain only the primaries. This also explains the observed azimuth effect according to which, at sea level along the equator, the number of particles coming from the west is greater than the number coming from the east. It may be predicted furthermore that the energetic bursts and showers will increase rapidly near the top of the atmosphere; and this has been brilliantly confirmed by the results of V2 rocket flights in which automatic apparatus has recorded such phenomena at great altitudes.

It is estimated that approximately one milligram of these primary particles fall upon the earth in one year. On the other hand, the power that they deliver to the earth is about one million kilowatts and is spent chiefly in producing ionization in the atmosphere. The sun delivers to the earth one hundred million times as much power.

The origin of cosmic rays is still a mystery. They may arise during the phenomena accompanying the birth of novae; but if they have their origin in such local occurrences they must suffer highly effective scattering in their passage through space, since they apparently traverse free space equally in all directions. Radiation pressure from the stars serves to provide interstellar space with charged and uncharged particles. If electric fields exist in interstellar space, they may provide the energy that these particles are observed to possess.

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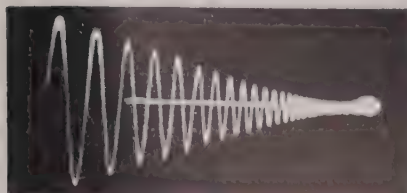
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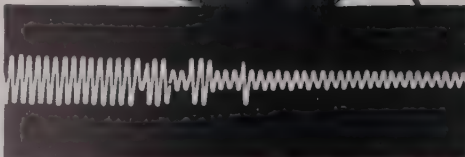
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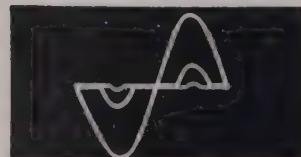
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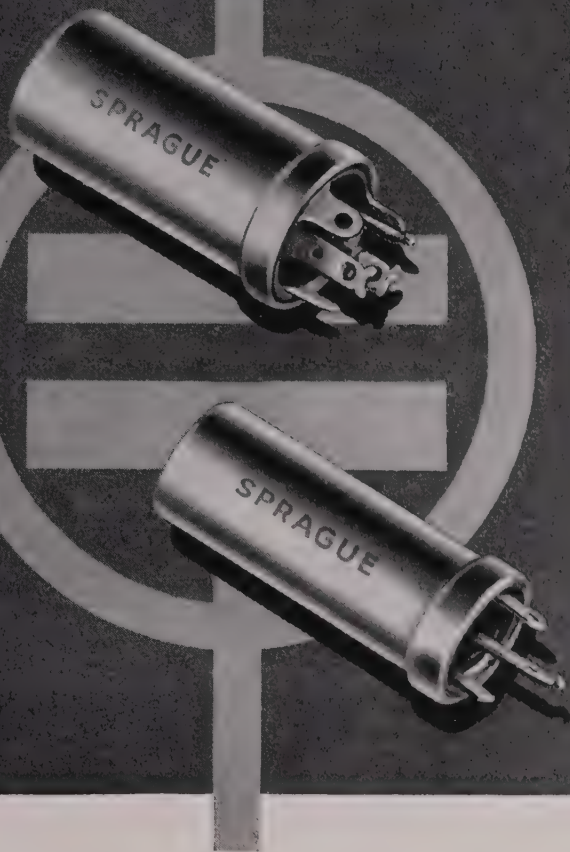
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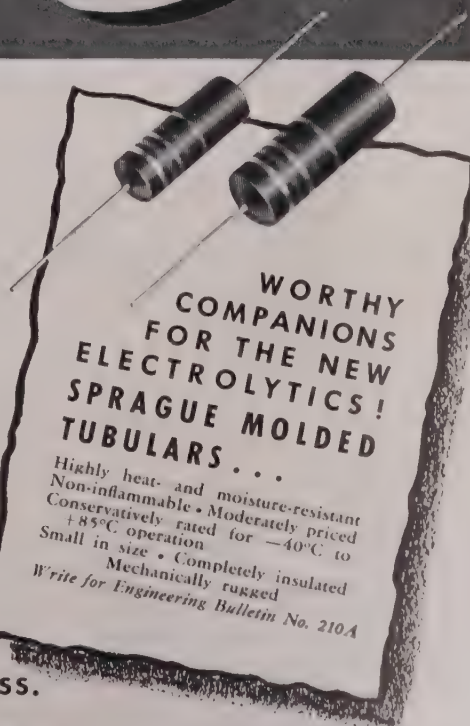


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PRACTICES AND TRENDS IN STEEL-MILL CONTROL

Improvements made in amplidyne and electronic control represent steps toward simplified systems to meet the ever-increasing demands for more automatic control

By A. W. SCHMITZ

Control Engineering Division, Apparatus Department
General Electric Company



A. W. Schmitz

IN THE making of steel, many types of machinery in various sizes are available to perform the numerous operations necessary for producing a finished product. Many of these operations are controlled by electrical means. Some require driving motors ranging in size up to 5000 hp or more; others, where the operation is of a process nature, require a large number of small motors. Electrical equipment is being used extensively, with control incorporating many automatic features. The use of such equipment has done much to improve the steel quality and output.

The electrical manufacturer who builds these motors and controls is continuously confronted with new requests to provide more and more automatic control with its endless chain of self-operating and self-regulating functions. These requests are initiated by the ever-increased demands for higher and higher mill speeds, greater rates of acceleration and deceleration, closer operating accuracies, and faster response. These and many other demands have been partly met through the

use of such tools as the rotating or static amplifier and the rotating or static control devices.

The complexity of modern controls, with the ever-increasing number of automatic functions, is of concern to mill operators and maintenance men. The electrical manufacturers are continually trying to simplify not only the circuits and devices, but also the arrangement and accessibility of the control.

Control Practice

Mill equipment, with all its ramifications and variations, has been grouped into three basic classes of application: auxiliaries; processing lines; and main-roll drives. The controls for these applications have many variations, not only in electrical functions, but also in mechanical requirements. Electrical functions refer to means for obtaining definite operating characteristics such as generator voltage regulation, etc. Mechanical

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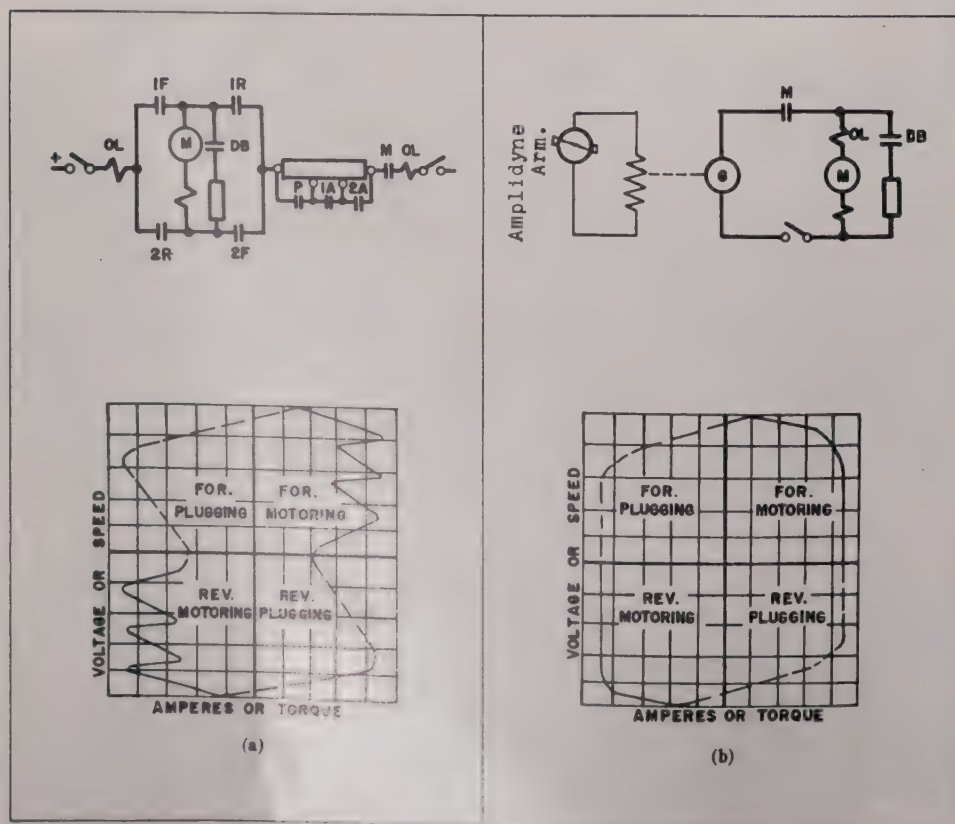


Fig. 1. Motor armature circuit and performance curves for two types of auxiliary control: (a) constant-voltage, plugging, dynamic braking; (b) adjustable-voltage amplidyne-type, plugging, dynamic braking

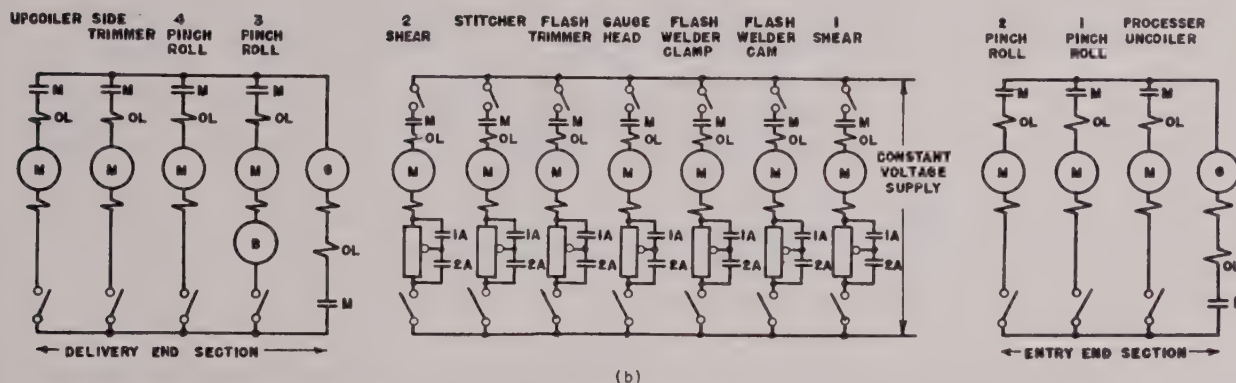
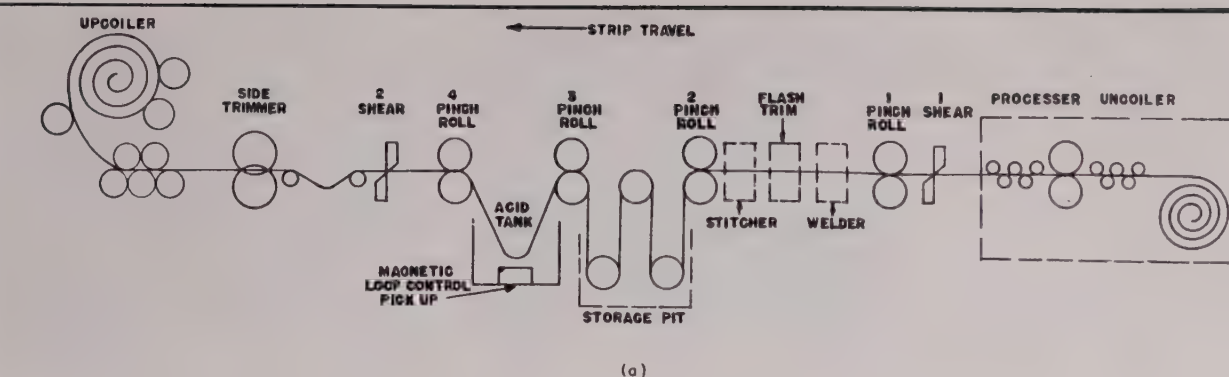


Fig. 2. The flow of material and grouping of motors in a pickling line: (a) arrangement of drive; (b) motor armature circuit with jogging and dynamic braking features omitted

requirement includes: physical size of a control panel; type of panel construction; and suitable arrangement and grouping of the operator's control devices.

A brief description of these applications, with the types of control having widespread use in present-day practice, is presented in the following.

Auxiliaries

Mill-type auxiliaries, which consist essentially of independently operated single-motor drives, are used extensively and in numerous places. Constant-voltage control is used to a large extent and utilizes the well-known magnetic time-delay relay for motor acceleration.

Adjustable-voltage amplidyne-type control is used frequently on reversing hot-mill tables, sideguards and screwdown drives, and many other important applications where fast repeating operating cycles are required. Better performance, along with several other advantages, are obtainable with this type of control. One of its outstanding features is uniform motor currents, instead of peaks and valleys, during the periods of acceleration, deceleration, and plugging (**Fig. 1**).

Processing Lines

Processing lines perform several operations in one continuous process in the manufacture of strip steel. Annealing, plating, cleaning, and galvanizing are typical examples of such processes. The number of d-c driving

motors depends upon the number of operations involved. Twenty or more motors may be required, and the requirements seem to be steadily increasing. The schematic diagram in **Fig. 2** illustrates an arrangement used in a pickling line.

Adjustable-voltage control is used nearly always on processing lines to obtain the maximum speed range. Adjustable voltage inherently provides the required flexibility to operate sections of a processing line at different speed levels with separately and independently controlled generators. Some lines, where the entry and delivery sections may necessitate momentary stopping to perform certain operations, require two separate generator sections which provide power to prearranged groups of motors. The number of automatic control functions is continually increasing for processing lines. These functions include regulation of storage loops, strip tension, motor speed, automatic follow-up, and many others.

Main-roll Drives

Main-roll drives refer to metal-reduction mills of either the hot- or cold-rolling type.

Single-stand reduction mills may be of the reversing or nonreversing type, and multistand tandem reduction mills are of the nonreversing type. Single or multiple generators have been used, and single driving motors or a group of driving motors may be connected to the same or different loads. The range in motor-

horsepower requirements on main-roll drives varies extensively and reaches thousands of horsepower.

The control for main-roll drives is subject to many variations and modifications which are usually dictated by the peculiar operating requirements of the particular drive. Adjustable-voltage amplidyne-type control finds its greatest use on these drives because of its maximum operating flexibility and inherently fast response.

Depending upon the type of drive, the control may include any one or a combination of the following control functions: voltage regulation, speed regulation, current regulation, tension regulation, and position regulation. Each of these regulating functions incorporates definite protective control limits and may include many other additional automatic features such as: load balancing between motors connected to the same load; ohmic-drop compensation of the armature loop circuit; WK^2 compensation to maintain uniform tension during periods of acceleration and deceleration, etc.; and, always, the required system stabilizing features. The grouping and arrangement of the mill operator's control devices to meet operating requirements differs with each job. It must extend the greatest degree of accessibility to the mill operator, with finger-touch control available at strategic locations. Fig. 3 shows an arrangement of a two-stand tandem skin-pass mill.

Trends

Increasingly more time and study are allocated towards control improvement. Control devices, circuits, and whole control systems are continually under investigation to obtain further refinements in performance and simplicity. In many instances, critical operating requirements are simulated in control manufacturers' laboratories to predetermine the performance of a device, circuit, or system.

Improvements directed toward the simplification of circuits and their devices, as well as arrangements and accessibility of the control, have been made with the following new features in amplidyne and electronic control.

Amplidyne Control

The associated components required with amplidyne-type control systems normally consist of small adjustable resistors, metallic rectifiers, capacitors, transformers, and small indicating instruments. The physical location of these associated parts has usually been on the back of the control panel board. The supporting method used for mounting the parts has varied from special brackets to elaborate shelves on large self-supporting panel structures, depending upon requirements.

These component parts, formerly mounted at various locations around the control panel boards, are now located and neatly arranged into a "package unit," well protected and designed for maximum ease of adjustment. Conventional tube-type resistor units are being replaced with small rheostats arranged to be locked in position when adjustments are complete. Instruments are provided on the front cover to aid in

making adjustments. Toggle switches are furnished for quickly changing the RC circuit constants when adjusting for system stability. All of the adjustable-control devices, which may need readjustment when the drive is put into operation, are in full view and clearly identified when the hinged front cover is opened (Fig. 4). The package unit may be mounted on the front or back of the control panel board, or it can be recessed into the panel.

Electronic Control

Electronic control is used extensively in many industries and is gradually finding its way into the steel

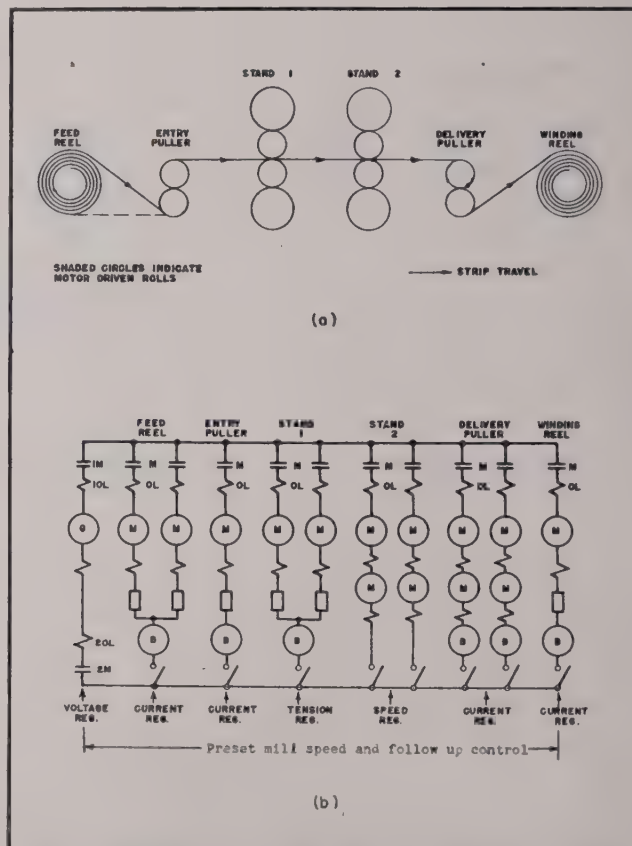


Fig. 3. Arrangement of a two-stand tandem skin-pass mill: (a) arrangement of drive; (b) motor-armature circuit connection

mills. Many difficult problems have been solved by the application of tubes, and many more problems will be solved in the future. Thus far, the acceptance of tubes for general mill work has been confined to independently operated single-motor drives. The reluctance on the part of the mill operators to accept tubes on continuous production lines is attributable to the constant fear of costly shutdowns in case of control failures. The basic objections expressed by mill operators are: unfamiliarity with electronic circuits and tubes; breakage of the physically small component parts; and the inherent danger of common ties between high- and low-voltage potentials because of possible grounds.

A new regulating control system of the amplidyne-electronic type has been developed. This control will minimize, if not completely eliminate, many of the aforementioned objections. It incorporates the con-

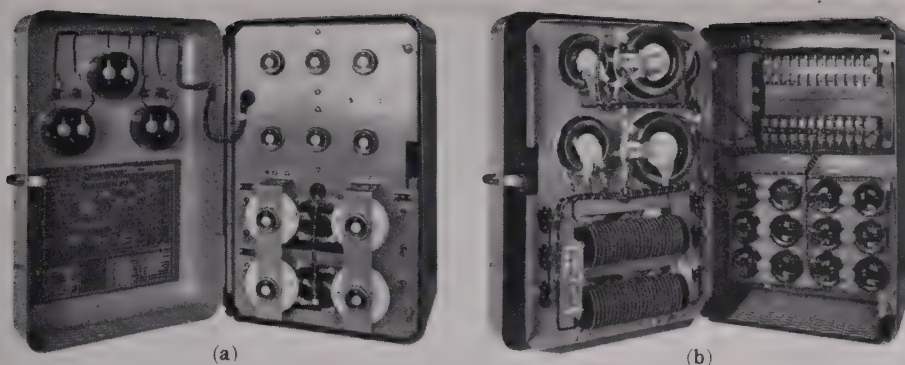


Fig. 4. Package amplidyne-type control unit used on a current regulator to control strip tension for a cold-strip-mill winding reel: (a) front compartment opened; (b) inner compartment opened

interchangeable and incorporate an unusual combination of ideas, including the so-called push-pull feature.

A voltage isolator, also of drawout-type construction, has been developed. It may be used with the electronic control to eliminate the common tie between the high- and low-voltage potentials and operates on the magnetron-tube principle. The physical size and arrangement of this drawout unit is the same as

that of the power supply unit shown in Fig. 5.

Conclusions

This article has been confined to a general description of mill-type control and does not include the well-known d-c magnetic type of control for mill auxiliaries and the circuit details of the various functions. Adjustable-voltage and adjustable-voltage amplidyne-type control have been featured in the article because of their wide use in modern steel mills.

The advanced data taken in laboratories on performance of control devices and circuits under simulated operating conditions are of considerable importance to the manufacturer and the ultimate user. The final result thus obtained may well mean the elimination of many hours of time which would otherwise be spent for experimentation in the steel plants.

Simplification of control, particularly on co-ordinated control equipments, is of vital concern to all. Amplidyne control in a package form provides desirable features from the standpoint of standardization and ease of adjustments. The new features incorporated in the amplidyne-electronic control minimize the mill operator's objections to the use of electronic control on continuous-process equipments. The amplidyne-electronic combination offers many advantages and will solve many problems arising in the future.

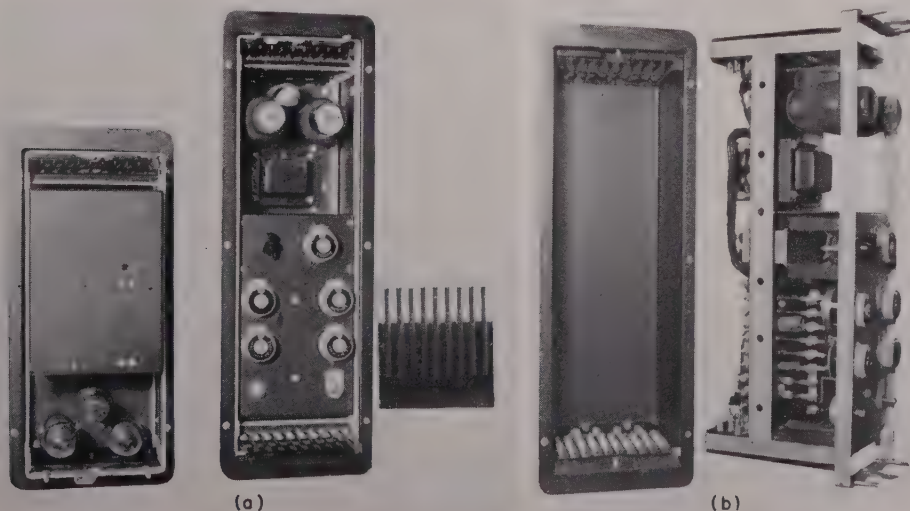


Fig. 5. Electronic control drawout unit and power supply for use with amplidyne-type control: (a) with front covers removed and amplifier unit disconnected; (b) amplifier unit withdrawn



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QUALITY TESTS OF MERCURY BUTTONS MADE AUTOMATICALLY

How mechanics, electronics, and electric circuits have been ingeniously combined in developing testers to rapidly and reliably check performance of button-type mercury switches

By K. T. SUTTON

Bridgeport Works Laboratory, General Electric Company



K. T. Sutton

THE mercury switch with which this article is concerned is designed for use as a wall switch for lighting and appliance circuits within its 10 amp rating and is especially suited to circuits where quiet operation and long life are required. It is called a mercury button switch because its flat cylindrical shape resembles a thick button.

As usually constructed, the mercury button has a $\frac{7}{8}$ in. over-all diameter and a $\frac{1}{2}$ in. axial thickness. It is made by sealing two metal cups together with glass, in the form of a sandwich, with a ceramic barrier between to insulate the cups, which are the respective poles or terminals of the switch. The barrier has a hole through it, offset from center; adjacent to the hole is a deep hollow called a blind hole. The button must be installed with the barrier in a vertical plane, and with the hole near the bottom.



Fig. 1. The assembly of a single-pole mercury button switch, and its component parts

The interior of the button is partly filled with mercury, the remaining space being filled with mercury vapor and a gas inert to mercury and under pressure higher than atmospheric. It is mounted in a handle or similar support so that it can be rotated about its axis through about 45 deg. The quantity of mercury and the internal volume determine the operating angle. Slight rotation from the central, or OFF, position dips the hole into the mercury, allowing the two pools, one in each cup, to contact each other through the hole in the barrier and so complete the circuit. Slight rotation in the opposite direction lifts the hole out of the mercury and breaks the circuit by imposing the ceramic barrier between the two pools of mercury.

A molded Textolite housing has suitable bearings on which the button shells rotate. It also has molded supports for the two contact strips which combine wiring terminals with contacts for the movable button. Two laminated Textolite pieces, pushed in at the top and bottom, hold the contact strips in proper position. A molded Textolite trigger fits the contour of the button, and has two lugs, or raised areas, which fit into the notches of the shells for turning the button through its operating angle. The frame has a spring-wire arc on each side of the cutout for the trigger. These springs supply the pressure to hold the trigger in contact with the button and maintain it in any setting within its operating angle. The frame is attached to the housing with two small screws and is made to fit all standard wiring boxes and wall plates.

Fig. 1 shows only the single-pole switch and its assembly. Other switches are all made in a similar manner but may carry up to four buttons per switch and still fit the standard box. Only two types of buttons are used in all these combinations: the single-pole and the three-way button.

As production of mercury button switches increased, it became desirable to introduce specially designed test fixtures which would facilitate high production rates. As the result, two types of automatic fixtures (one an operating-angle and arc-duration tester, and the other a resistance tester) were designed and built. These are now in regular use, speeding up the button output and maintaining consistently higher button quality.

Previously the angle tests had been made in a calibrated jig in which the button was held with the notch (in one of the metal cups) at an angle of 45 deg to the horizontal, then swung through an angle equal to twice the regular operating angle. Indications of circuit closure and opening were given by a pilot lamp and a five-volt transformer in series with the button. The arc-duration tests had been made on a separate hand fixture in which the operator swung the button through a predetermined fixed angle while an electronic circuit measured the arc-duration time, indication being made on an instrument whose deflection is proportional to the time of charging a capacitor. Too long an arc duration delayed voltage recovery, increased capacitor charging time, and so gave an instrument deflection beyond the calibrated point for a good button.

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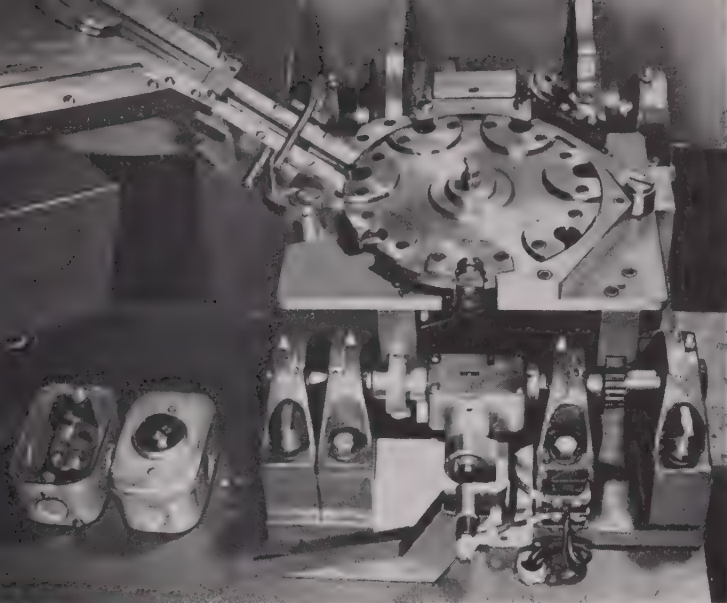


Fig. 2. Automatic arc and angle testing machine used in the high-production testing of the mercury button switch

Angle and Arc-duration Tests

One of the new production-testing machines was designed to perform both the angle tests and the arc-duration tests. It includes a test head which tests the buttons as required by the specifications, by making a circuit five times out of five tries with no long arc duration when swung between the maximum and minimum angles, and includes also various other mechanisms for properly handling the buttons and delivering them to the test head.

Mechanical Operation

The hopper (Fig 2) is an inclined plane upon which the buttons lie flat with the weld side up. A safety glass cover is placed just one button height above the floor of the incline, so that no button can tilt up onto another and thus jam the hopper. An agitating mechanism keeps the buttons moving along the feed track to the indexing dial.

The indexing dial has seven stations, or button holders, that are filled individually from an escape mechanism in the feed track from the hopper. The dial moves in synchronism with the test head so that the station and test head both arrive at the proper place at the same instant. A ratchet arrangement on the test-head mechanism drives the indexing dial, and a friction brake prevents coasting of the dial. The dial moves only while the test head is swinging up from the test position, and buttons are fed from the escapement only when the dial is standing still.

When the dial moves, the button shell it has just received is pulled along an indexing band which rotates the button in the station until the notch catches over a spring-loaded index pin. When this occurs, the button is pushed further into the station so it no longer contacts the indexing band, and it is carried around to the test head without further rotation.

The indexing band is a steel block shaped to conform to the outside edge of the indexing dial, with a groove along its length to accommodate the glass seal of the

button. A small flat spring is located in this groove to press against the glass and hold the button seated in the station when it has indexed. The front face of the indexing band has very small sharp teeth, similar to those of a file, milled into it, which contact the upper shell and cause rotation of the button. The indexing band is spring-mounted so that it can move only in a radial direction to the dial and has adjustable stops to prevent it from contacting an indexed button. (A switch with a lever is mounted next to the indexing band to light a pilot lamp automatically if a button passes without being indexed.) The buttons are then carried around in the indexed position to meet the test head.

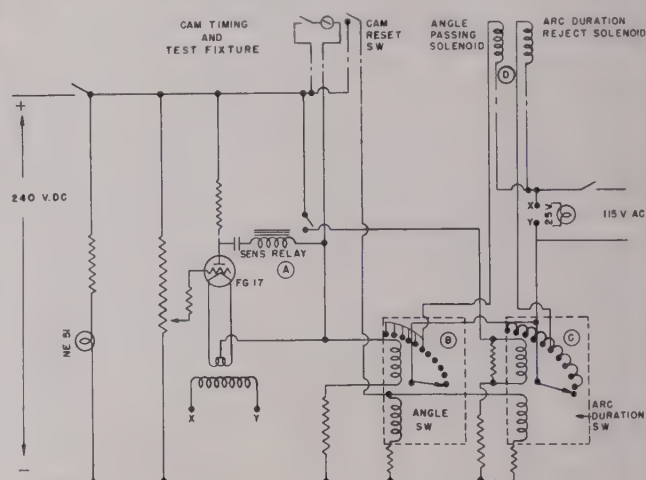


Fig. 3. Circuit diagram of the electric unit used in the automatic arc and angle testing machine. (A) sensitive relay; (B and C) step switches; (D) solenoids

At the beginning of the test cycle proper, the test head is in its down position as shown in Fig. 2. There it holds the button in the vertical plane and radially oscillates it back and forth through the required angle six times; then drops it into a sorting chute. The head then swings upward through 90 deg, picks the next button out of the horizontal indexing dial, and returns to its down position to repeat the testing cycle. The entire cycle takes only four seconds; the rate of testing is five swings in two seconds.

When the buttons are dropped into the chute, they are sorted into three groups: good, arc rejects, and angle rejects. This sorting is accomplished by solenoid-operated trap doors in the chute. The solenoids are energized by the electrical unit which interprets the results of the multiple tests.

Electrical Operation

After the first complete swing of the button has been made to distribute the mercury evenly on both sides of the ceramic barrier, the electrical tests are made. A cam timing switch applies 250 volts d-c across the test head after the first swing and removes it after the sixth. The electrical circuit for the machine (Fig. 3) is similar to that used in the earlier arc-duration test made by hand, but it has several additional features.

The angle tests are made by passing the load current through the operating coil of a step switch of the tele-

phone type. When the coil has stepped five times, contact is made to energize the angle solenoid which closes the first trap door in the sorting chute, and passes the button for angle. Less than five operations of this switch leaves the trap door open, and the button is rejected.

The arc tests are made with circuits similar to those used earlier with the hand fixture. However, a sensitive relay is substituted for the instrument that was employed in the hand-fixture circuit. Whenever a bad arc occurs, this sensitive relay in the new tester closes the operating circuit of a step switch the contacts of which are in the circuit of a solenoid that opens the normally closed trap door. Thus, even one bad arc is sufficient to cause rejection of the button.

The electric unit (Fig. 4) operates these trap doors before the button is dropped and holds them until the whole circuit is cleared by the momentary closing of the cam switch in the reset circuits. This switch operates when the test head is dropping down to the test position with a new button.

Resistance Tests

In addition to tests for angle and for arc duration, resistance tests must be made. These also had previous-

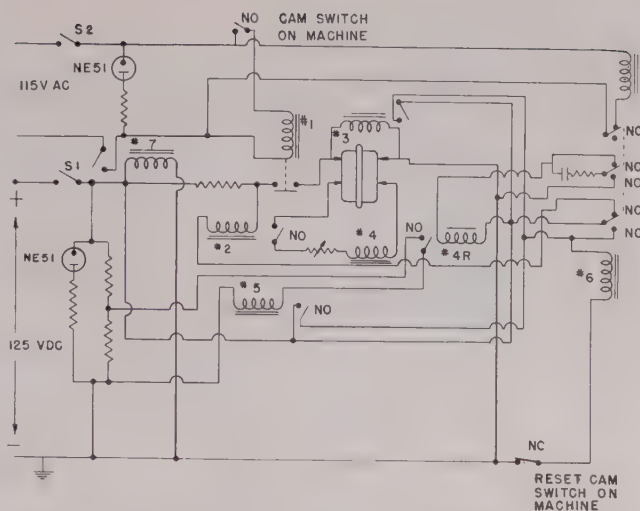


Fig. 5. Circuit diagram of the electric unit used in the automatic resistance-testing machine

of mercury-plunger type, applies 10 amp d-c through the button. If the circuit is completed, Relay 2 then pulls in after suitable time delay and closes sensitive Relay 4 across the button. A button with high resistance causes the contacts of Relay 4 to close in the circuit of the low-voltage slave Relay 5. The contacts of Relay 5 close the locking Relay 6, which opens the solenoid circuit, rejecting the button. Similarly, an open button will cause Relay 3 to close and energize the locking Relay 6, which again rejects the button. Relay 6 remains closed until the normally closed cam-operated reset switch is tripped by the machine to clear the circuit before the next test. Fig. 6 shows rear view of the electric unit of the resistance tester.

Both the angle and arc-duration test machine and the resistance test machine are made with spring-loaded cam followers to prevent damage to buttons or fingers that might happen to get into the wrong places. The followers also prevent the test head from smashing itself against the dial or crushing buttons. The heads of both machines are made up in such a way that a check can be made of the angle without making an elaborate set up; a protractor can be placed between the head and the base plate for a quick check of angle. Both electric circuits are so designed that in case of power failure on either the a-c or the d-c circuits the buttons will all be rejected.

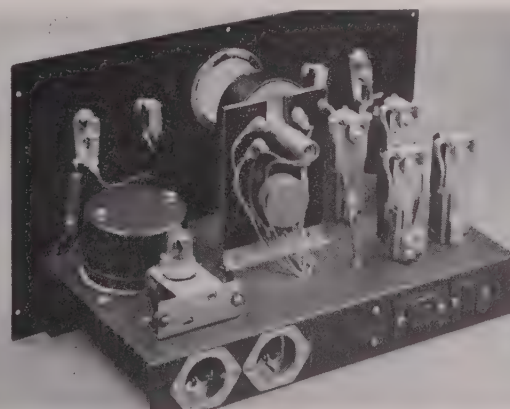


Fig. 6. Interior view of the electric unit of the resistance tester

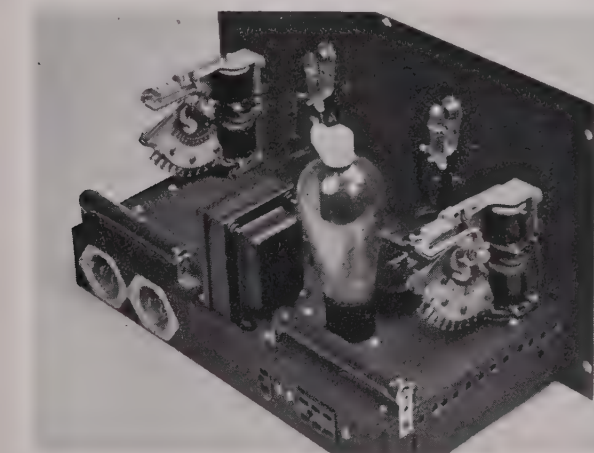


Fig. 4. Interior view of the electric unit of the arc and angle tester

ly been made in hand fixtures. For the new high-production program, an automatic resistance tester was designed very similar in external appearance to the angle and arc tester previously described.

Mechanical Operation

This automatic resistance tester handles the buttons from a hopper in the same manner as before but the machine runs at twice the speed of the angle and arc-duration tester. The test head is also somewhat different in that both sides of the button holder open and close, that it carries four contacts, turns the button ON, and does not rotate it through the cycles as does the other machine. There is a shift knob on the right-hand end which must be changed to test single-pole or three-way buttons because they must be held at different angles.

Electrical Operation

The electric circuit of this machine is shown in Fig. 5. Relay 7 is only an interlocking relay which shuts off the a-c supply in case of failure of the d-c. Relay 1,

BACKGROUND TO ACHIEVEMENT



Wellington ★

—the capital of New Zealand, with its magnificent deep water harbour, is situated in the south western corner of the North Island. Not only politically, but also geographically and commercially, it is the hub of New Zealand.

★The famous BTH name is much in evidence in Industrial and Municipal undertakings in Wellington. Equipment for the entire electric tramway system is, for example, predominantly BTH. Masda Lamps, too, make a great contribution to the city's lighting. The main electricity supply to the city passes through two 30,000 kVA transformer banks and 11 kV switchgear — all BTH.)

Electric trains and trams ply between the city and its extending suburbs. Electric supply comes from the Government system of interconnected hydro-electric stations, while the city's own quick steaming plant acts as a standby.

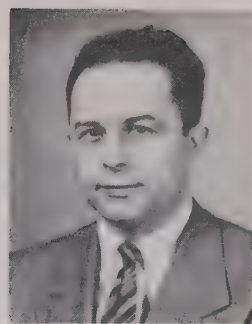


I.A.108

THE BRITISH THOMSON-HOUSTON COMPANY LIMITED, RUGBY, ENGLAND

AN AID TO FILING ANALYTICAL CHEMISTRY PROCEDURES

By HYMAN KIRTCHIK
Thomson Laboratory, River Works
General Electric Company



Hyman Kirtchik

PROBABLY every laboratory doing a large variety of chemical analysis has at one time or another been confronted with questions as to how best to file the records of the procedures used. Of filing systems intended to solve that problem, the author believes that the one now in use at the Thomson Laboratory merits wide consideration because its nomenclature furnishes a *complete* explanation of the analytical procedures involved. This it does by a code system which eliminates the use of indexes and long titles, and instead utilizes designations readily understandable to all concerned. Hence the method not only facilitates filing but also provides for easy and quick reference.

The system is divided into the following seven main groups, each designated by a letter:

- C = Cleaners, pickling baths, solutions
- E = Commercial elements
- F = Ferroalloys
- H = High-temperature or heat-resistant alloys
- M = Miscellaneous (not otherwise classified)
- N = Nonferrous alloys
- S = Steels (plain and alloyed) and irons.

One of those letters appears first in the code designation.

In groups **E** and **F** the major chemical element is identified by placing its symbol in parentheses. For example, **E(Pb)** is to be read as "metallic lead," and **F(Cr)** means "ferrochromium."

Group **N** is subdivided as follows:

- A = Aluminum alloys
- B = Babbitts
- BR = Brasses and bronzes
- MG = Magnesium alloys
- MI = Miscellaneous (all others)
- SO = Solders.

These letters appear after the **N**.

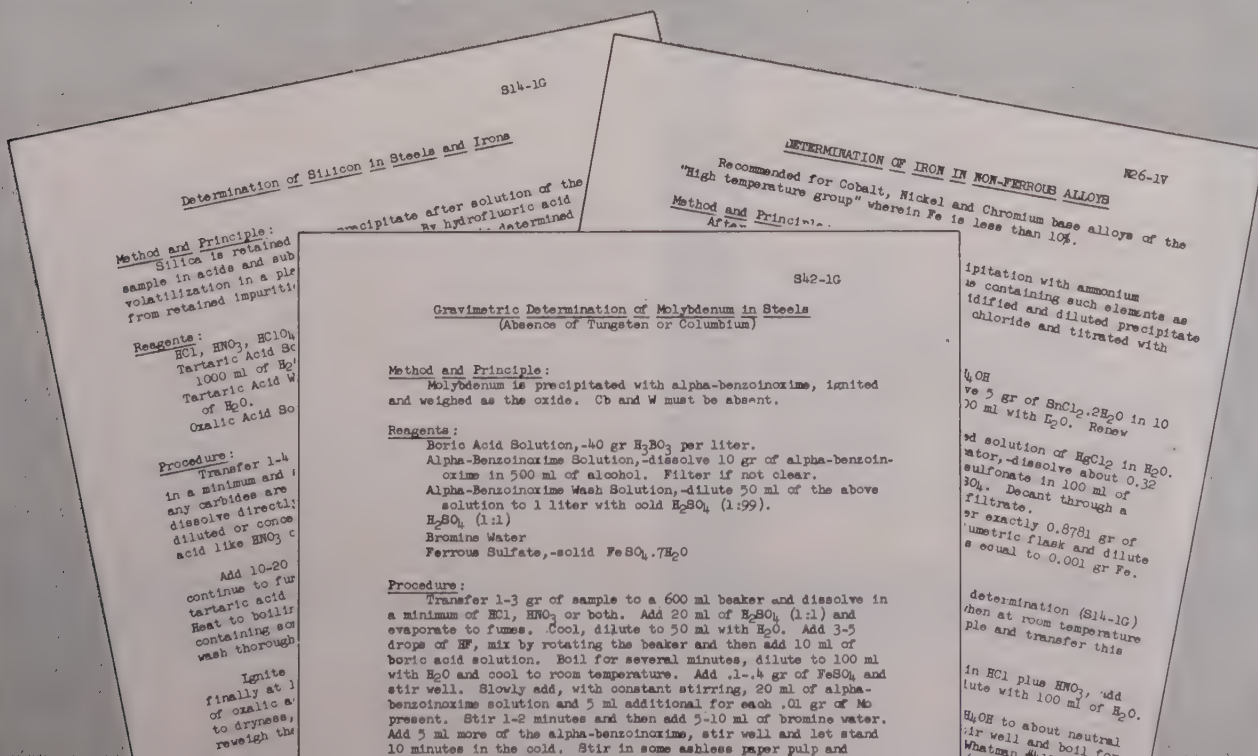
In the filing system here described, each chemical element is designated by its atomic number (the number of its position in the periodic table of elements). This numerical designation is followed by a dash (—).

Examples: Carbon is 6—; copper is 29—.

Following the dash is the number 1, or 2, etc., which indicates that the method used is the first, or second,

This article is so paged that, without mutilating other articles, it can be conveniently removed for separate filing by tearing out pages 43 to 44.—Ed.

Three typical record sheets of chemical analytical procedures as prepared for filing at the Thomson Laboratory



etc., that has been utilized in the Laboratory for making chemical analyses of the element concerned.

Examples: The first sulfur method is indicated as 16—1; the second sulfur method as 16—2.

To record the type of chemical analysis, there appears next in the code sequence one or another of the following pertinent designations:

- C = Combustion
- CL = Colorimetric or photometric
- E = Evolution
- EL = Electrolytic
- G = Gravimetric
- P = Potentiometric
- PO = Polarographic
- SP = Special method
- V = Volumetric

Examples:

- S16—1E is the first method for determining sulfur in steels by evolution
- NA25—1V is the first method for determining manganese in aluminum alloys volumetrically
- E(Co)28—1G is the first method for determining nickel in metallic cobalt gravimetrically
- H22—1CL is the first method for determining titanium in high-temperature alloys colorimetrically.

When a method is revised or superseded, small letters—*a, b, etc.*—follow the number after the dash.

Example: A correction issued on S16—1E would be S16—1aE.

When a single analytical method gives more than one element, such as silicon and tungsten in steels, the code shows both atomic numbers in numerical sequence as S14, 74—1G.

As listings, the methods are filed alphabetically according to the seven main group letters—*C, E, F, H, M, N, and S*; and—under each letter—numerically by atomic number. Examples are given in Table I together with their explanations.

TABLE I
EXAMPLES OF FILING SYMBOLS AND THEIR EXPLANATIONS

Symbol	Explanation
E(Ag)29—1EL	Electrolytic determination of copper in metallic silver
E(W)42—1CL	Colorimetric determination of molybdenum in tungsten
F(B)26—1V	Volumetric determination of iron in ferroboron
F(W)14—1G	Gravimetric determination of silicon in ferro-tungsten
H6—1C	Combustion carbon determination in high-temperature alloys
H25, 26—1aV	Revised volumetric determination of manganese and iron in high-temperature alloys
NBR30—1G	Gravimetric determination of zinc in brass
NMG13—1G	Gravimetric determination of aluminum in magnesium alloys
S7—1SP	Special method for the determination of nitrogen in steel
S15—1V	Volumetric determination of phosphorus in steel
S16—1E	Evolution method for the determination of sulfur in steel
S23—1P	Potentiometric determination of vanadium in steel

All procedure records are hectographed on standard-sized paper, with the complete code number typed in the upper right-hand corner for easy thumbing. Included also are the full title and identification of the method, apparatus, reagents, etc., that were used. For convenience, when more than one page is necessary to contain the descriptive matter, the pages are numbered consecutively at the bottom. When a single page is sufficient, the numbering is omitted so that the analyst knows immediately that the procedure ends on that page.

The system described is based, not upon an abstract numbering code, but upon one in which the symbols have obvious significance. Reference to a chart containing the main code symbols and atomic numbers is all that is required.

NEW COMPACT CONTACTOR..

3 Sizes up to 100 Amp

Ward Leonard's new design of a-c solenoid contactor—maximum capacity in minimum space—is now available in three sizes from 25 to 100 amp rating. This contactor, designed to meet machine tool requirements, is compact, sturdy and requires a minimum of maintenance.

Write for Bulletin 4451. WARD LEONARD ELECTRIC COMPANY, 62 South St., Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada. Resistors • Rheostats • Relays • Control Devices.



WARD LEONARD ELECTRIC CO.

Result-Engineered Controls

**Q. what is the correct
brush pressure?**



A- *See Speer!*

Too much depends on type of brush and brush holder and on the condition and speed of the commutator to make iron-clad rules for the best brush pressure. The only way of determining *exactly* the most economical and efficient ratio is by actual test.

Speer Carbon Company engineers are equipped to make such tests for you. Out of their years of experience in the manufacture and application of brushes, they'll give you a recommendation for the most efficient spring pressure—and at the same time, recommend proper brushes for all-around, better performance.

Whenever it's a question of brushes, take advantage of our research and experience. Call in a Speer engineer.


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HIGH-VOLTAGE RECTIFIER CIRCUITS . . . Part IV

Commonly used filter circuits, their characteristics, and points to be considered when determining the rating of each component

By E. V. DeBLIEUX

Power Transformer Engineering Division
Pittsfield Works, General Electric Company

STRICTLY speaking, any modification of the rectifier circuit that reduces the ripple in the output voltage functions as a rectifier filter. The commonly used filter circuits are shown in **Figs. 13 to 16**. In addition to these methods, increasing the number of phases (phase multiplication), because of the smoothing action, performs a filtering function.^(a)

Increasing the number of phases of the rectifier-winding connection to reduce the pulsations in the rectified voltage is a well-established practice in power-rectifier applications. Circuits that are the equivalent of as high as 72 phases have been used in large power-rectifier installations. For high-voltage rectifiers, it is not practical to extend this method beyond six phases (Circuits 5 and 6, Table I*), and frequently not even to three phases, because the current per phase becomes so small that the rectifier tubes will be working at considerably less than their rated capacity.

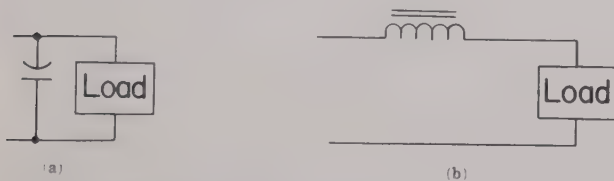


Fig. 13. Placement of capacitor and inductor when used for filtering: (a) shunt capacitor; (b) series choke

For the rectifier winding to have the desired mechanical strength, the conductor must not be below some definite cross-section size. Therefore, if the number of phases is increased, it may require, for small-current high-voltage rectifiers, working the conductor at less than its permissible rating or lowering of the mechanical strength of the rectifier winding.

Shunt Capacitor

A simple means for reducing the pulsations in the output voltage is to connect a suitable capacitor across the output terminals, as shown in **Fig. 13(a)**. A shunt capacitor can be used with any of the circuits shown in Table I^(b). The capacitors shown connected across the output terminals of the circuits of Table III† (except Circuit 1) also perform a filtering function.

The shunt capacitor functions as a filter because it tries to maintain a constant voltage across its terminals.

In the consideration of the mechanical analogy (Part III) is explained this voltage-smoothing action. The larger the capacitor, the greater is the reduction of the ripple voltage, but the peak value of the capacitor charging current, and therefore of the tube current, also increases with the size of the capacitor.

If the rectifier tube is a gas tube, the peak current may exceed the peak rating of the tube when large capacitors are used. If the rectifier tube is a high-vacuum type, the peak current will be limited by the tube-emission limit. But for either type of tube, damage to the tube may result if too large a capacitor for the tube rating is used.

In general, the use of a capacitor as a filter is preferable only when the load current is very small and resistors can be used to limit the peak charging current. If the peak tube rating permits, a capacitor of the proper rating can be chosen and the output voltage caused to approach closely the peak of the d-c secondary-winding phase voltage.

Series Inductor

A series inductor, sometimes called a choke, functions as a filter because it tends to maintain the current through it constant by storing energy during one part of the cycle and delivering it to the load during another part. The usual connection is shown in **Fig. 13(b)**. The use of a choke eliminates the high peak currents of the capacitor but has the disadvantage of decreasing the output voltage because of the impedance of the choke.

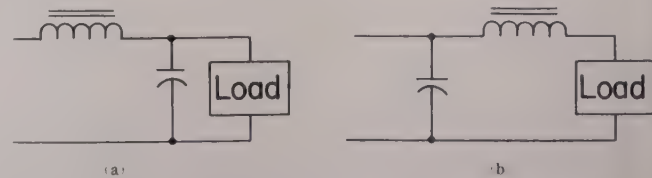


Fig. 14. Circuit arrangement for L filters: (a) induction-input arrangement; (b) capacitor-input arrangement

The rating of the choke required to produce a specified degree of smoothness in the output voltage increases rapidly with the amplitude of the ripple in the unfiltered voltage. A choke is preferably used in high-

(a) Methods for calculating the ripple in the d-c voltage are given in: "Rectifier Wave Shape," *EEI Publication EI*, April, 1937.

(b) Methods for calculating filter operation and other characteristics of Circuits 1, 2, and 3, (Table I), are given in: Electrical Engineering Staff M.I.T.: *Applied Electronics*, John Wiley & Sons, Inc., New York.

Other methods for making the calculations and for including the effect of inductance in the load circuit are: "Analysis of Rectifier Operation," by O. H. Schade, *Proc. IRE*, July 1943, p. 341. "Analysis of Rectifier Filter Circuits" by M. B. Stout, *AIEE Trans.*, vol. 54, Sept. 1935, p. 977.

*Table I appeared in Part II of this article in the March issue.
†Table III appeared in Part III of this article in the April issue.

This article is so paged that, without mutilating other articles, it can be conveniently removed for separate filing by the following pages 46 to 47.—Ed.

current rectifier circuits^(c) with small inherent ripple voltage.

Because the choke tries to maintain the current constant, and because polyphase circuits commutate in a manner that keeps the arc from extinguishing (and causing a high voltage across the choke), series inductors should preferably be used in polyphase circuits.

L Filters

Because of the limitations of the filtering arrangements considered in the preceding sections, combinations of capacitors and inductors in L or π type filters are commonly used.^(d)

When an L -type filter is used, the inductor is placed on the rectifier side of the capacitor (inductor input) if the load resistance is high, and on the load side (capacitor input) if the load resistance is low.

For the inductor input arrangement in Fig. 14(a), the reactance of the inductor should be high in comparison with the reactance of the capacitor. For the capacitor input arrangement in Fig. 14(b), the reactance of the inductor should be high in comparison with the load resistance.

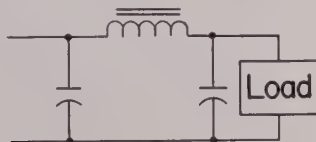


Fig. 15. The π filter, formed by adding a second capacitor to the capacitor-input arrangement shown in Fig. 14 (b)

For the capacitor input arrangement, high peak tube current may occur the same as with the simple shunt-capacitor filter. Fortunately, applications of high-voltage rectifiers requiring very smooth load voltage are usually high-resistance loads, and resistance can therefore be used to limit the capacitor inrush current with negligible effect on the load voltage. High reactance in the inductor produces effective filtering because it causes the ripple voltage to appear across the inductor, rather than across the load or the capacitor.

π Filters

This filter circuit^(e) Fig. 15(c) is a capacitor input L filter with a second capacitor added. It may seem that adding a second capacitor would be of little advantage and that the circuit would have the same

(c)For calculations of the characteristics of rectifier circuits with series inductors, see: Electrical Engineering Staff M.I.T.: *Applied Electronics*, John Wiley & Sons, Inc., New York.

(d)Analysis of this type of filter circuit is given in: Electrical Engineering Staff M.I.T.: *Applied Electronics*, John Wiley & Sons, Inc., New York, and "Analysis of Rectifier Filter Circuits," by M. B. Stout, *AIEE Trans.*, vol. 54, Sept. 1935, p. 977.

(e)Methods for calculating the characteristics of filter circuits are given in: E. E. Staff M.I.T.: *Applied Electronics*, John Wiley & Sons, Inc., New York, "Analysis of Rectifier Filter Circuits" by M. B. Stout, *AIEE Trans.*, vol. 54, Sept. 1935, p. 977.

(f)Formulas for determining the capacitance required to obtain the most effective filter are given in: "Rectifier Filter Circuits" by Ruben Lee, *The Electric Journal*, vol. 29, No. 4, April, 1932, p. 186.

(g)Methods for calculating the incremental inductance for large d-c current applications can be found in: "Direct-current Reactor Design," by D. C. Prince, *GENERAL ELECTRIC REVIEW*, June 1924, p. 380; and for small-current applications, in "Design of Reactances and Transformers Which Carry D.C.," by C. R. Hanna, *AIEE Trans.*, vol. 46, 1927, p. 128.

objections of high-charging capacitor current, but analysis of this circuit shows that the capacitor on the rectifier side can be smaller, and therefore the peak tube current will be less, than for the filter circuit shown in 14(b).

Furthermore, if additional stages are added (Fig. 16) a smaller total amount of inductance and of capacitance will be required than when a single stage is used, but



Fig. 16. Multiple-stage π filter, most effective when the ripple in the unfiltered voltage is small

the total cost may be higher because of the greater number of sections. Increasing the number of stages is most effective if the ripple in the unfiltered voltage is small. When π filters are used, the d-c voltage regulation increases rapidly as the load current increases.

The preceding paragraphs outline the advantages and disadvantages of the different types of filter circuits and give general guides for choosing the preferred filter circuit for a given application. Reactors and capacitors are energy storage reservoirs. Therefore the filter circuit that requires the smallest energy storage reservoir is theoretically the most economical. Generally, low-voltage filters have high capacitance, and high-voltage filters have high inductance^(f).

A filter in which the incremental inductance of the inductor decreases appreciably as the circuit current increases is an efficient type of inductor. By incremental inductance is meant the inductance of a coil through which a direct current and a superposed alternating current flow. Inductors that operate in this manner are sometimes called swinging chokes^(g).

Caution should be used in determining the preferred filter circuit and components. The determination of ripple voltage, capacitance, and inductance is approximate because in practical circuits the voltages and currents are not sinusoidal and the characteristics of capacitors and inductors are not linear. Fortunately, an approximate calculation of filter requirement is usually sufficient. If a high degree of accuracy is essential, preliminary calculations by the methods indicated and verified by experimental methods are recommended. Furthermore, the cost, size, and capacitance of high-voltage capacitors do not vary in a uniform manner.

In practical rectifier circuits the choice of rectifier and filter components is determined in large measure by the rectifier output characteristics, the degree of smoothing required, the ratings of available standard tubes, capacitors and inductors, and permissible weights and dimensions.

(Concluded)

HIGH LIGHTS AND SIDE LIGHTS

Yellow Enameled Lamps

Two new lamps for outdoor lighting have been announced—the 60-watt and 100-watt yellow enameled lamps, both of which have 1000-hour life ratings. The yellow enamel is a glass coating “fixed” on the bulb.

The substitution of yellow lamps for white lamps of equal wattage markedly and definitely reduces the number of insect pests attracted by any outdoor lighting. There’s no magic in it—the simple fact is that insects are less attracted to a yellow lamp than to a white lamp of equal wattage.

There is evidence that any kind of a light shining in the darkness has some attraction for night-flying insects, but the visual sensitivity of the night-flying insects is greater for white or blue lights than for red or yellow.

Therefore, when there are insects around, a yellow lamp out-of-doors will attract fewer than a white lamp. It is

sometimes desirable to put up two lamps, a white one at a distance and a yellow one nearby.

The lamps are made for use in doorways, barns, boat docks, gardens, garages, carnivals, picnic areas, parking lots, outdoor theaters, porches, roadside stands, pavilions, and summer camps.

Giant Magnet

A six-ton electromagnet, believed to be one of the largest and most powerful of its kind, has recently been built for Rutgers University. Although not designed for lifting purposes, it has a magnetic force equivalent to some 40,000 pounds, which would be sufficient in a lifting magnet to raise 13 automobiles of average size.

The huge electromagnet will be a part of the basic equipment in the new low-temperature laboratory at Rutgers and will be used in experiments requiring

generation of exceptionally strong magnetic fields over large areas.

It will help provide a means for reaching temperatures in the range of absolute zero, or 460 degrees below what is commonly called zero. Influence of the strong magnetic field on certain salts will remove heat to a degree such that these low temperatures can be reached.

The instrument also will be used to study magnetic susceptibility at low temperatures and to investigate nuclear magnetic properties of various isotopes.

The huge device is 56 in. long, 39 in. wide, and 20 in. high. The electromagnet’s two coils are 36 in. in diameter. The main body of the instrument, made of iron, weighs 10,000 lb; the coils, of copper wire, weigh 1000 lb each.

Despite its great size, the electromagnet is as precision-built as an expensive wrist watch, according to its designers. Pole faces of the magnet deviate from perfect parallel to the extent of only one half a mil, or one sixth the thickness of an average sheet of paper. Such precision was necessary in order to achieve a uniform magnetic field between the pole faces.

New Therapy X-ray Unit Yields to Modern Trend in Design

A radical departure in both the operation and design of x-ray therapy apparatus has taken place with the development of the Maximar 100. This is a superficial therapy unit designed especially for the treatment of skin ailments and providing more than *triple* the quantity of radiation per minute furnished by earlier models. In addition, it produces an extremely high proportion of “soft” or long-wavelength radiation, which does

not penetrate the surface, thus making it especially suitable for skin work.

For the convenience of doctor and technician, the tube and its stand can be adjusted and locked, with slight hand pressure, into any desired position.

The problems encountered in the designing of scientific instruments of this type are vastly complicated. The designers found that the long life and low volume required design that was direct, clean, and simple, that did not depend on trim or tricks for style, and that could be made of fabricated sheet, sand castings, and other “short-run” methods not requiring costly dies, molds, and tooling. Pre-established location of structural parts afforded limited leeway of design; and proper spacing for protective shielding tended to control the shape, which had to be pleasantly and practically contoured.

A new soft and restful pearl shade, glossy finish, was selected as standard to replace the depressing dead-black, hard-to-clean crackle finish common to this type of equipment. The new cheerful color is said to have a favorable psychological effect on both patients and operators.

Matching controls have instruments grouped for maximum ease and efficiency of operation within mechanical and structural limitations. Dials are illuminated by light-transmitting plastics and resemble modern radio dials, further stressing the pleasing “new look” that has invaded the scientific equipment field.

Mobile Meter and Instrument Exhibit

“Instruments in Industry,” a mobile exhibit of more than 150 electrical measuring devices, rolled into New York in March on the first lap of a projected tour which will take it throughout the United States by the middle of 1949.

The exhibit was presented for utilities engineers and executives from industrial firms in the New York City area.

Eighteen panels which display electrical measurement devices and a screen for the presentation of descriptive slide films comprise the physical properties of the exhibit, which can be dismantled, packed in crates, and loaded on a single truck in a few hours.

Each panel covers a different type or class of instruments. The complete presentation includes switchboard, panel, and aircraft instruments; instrument accessories or components; photometric devices and photovoltaic cells; time switches; portable testing instruments; remote position indicators; recording instruments; instrument transformers; laboratory instruments; watt-hour meters; and telemeters.

To supplement the physical display of instruments, some of which can be operated manually on the panels, brief illustrated talks are presented on their operation and their commercial, industrial, and home application.

Following its initial public presentation in New York, the “Instruments in Indus-

New x-ray therapy unit, in operation, proves not only pleasant to look at but easy to handle



try" exhibit traveled to the Midwest. Other stops on the nationwide tour now are being scheduled.

Plastics Sealing Sleeves Insulate Magnetic Coils

Plastics sealing sleeves form a new tough, tight-fitting insulation for magnetic coils. The new process, which permits the covering of all inner and outer surfaces in one operation, is accomplished by slipping a sealing sleeve inside the magnetic coil, turning the two ends over the outside, and permitting the sleeve to air-dry. Use of the sealing sleeves as an insulation enables many coils to be wound as one piece on long mandrels and cut to desired size.

The sealing sleeves are also finding use as coverings for cable ends; grips for pliers, wrenches, and wire cutters; and as temporary protective covers for the storage and shipment of finished products.

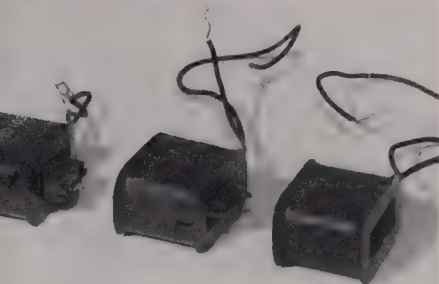


Illustration of the use of plastics sealing sleeves to insulate magnetic coils

Processing the plastics sleeves calls for a special dilator solution in which the material is immersed from two to four hours. When expanded to half again its normal size, the sleeve is placed in position. As it dries it shrinks to smaller than its original size, forming a tight fit around the product.

New Radio Channels Opened

A new radio system which by relatively simple means will double the number of signals usually accommodated in a given radio band, by permitting transmission or reception selection of either of the two sidebands which carry radiowaves, has just been announced.

Basis of the new system is the fact that radio signals travel in two sidebands along the unused carrier wave, like two busy highways running parallel to one which is never used. Using the new method, known as Selective Sideband Transmission and Reception, it will be possible to choose the radio highway that is desired. And if there is heavy traffic on one, the second can be used.

Outdoor Substations Increase Production

An increase in production, a 50 per cent reduction in line losses, and a saving of 75 per cent in installation costs have resulted from the installation of two 1000-kva, outdoor-type, load-center unit substations at a large Southern textile mill. A third unit of the same rating will be installed soon.

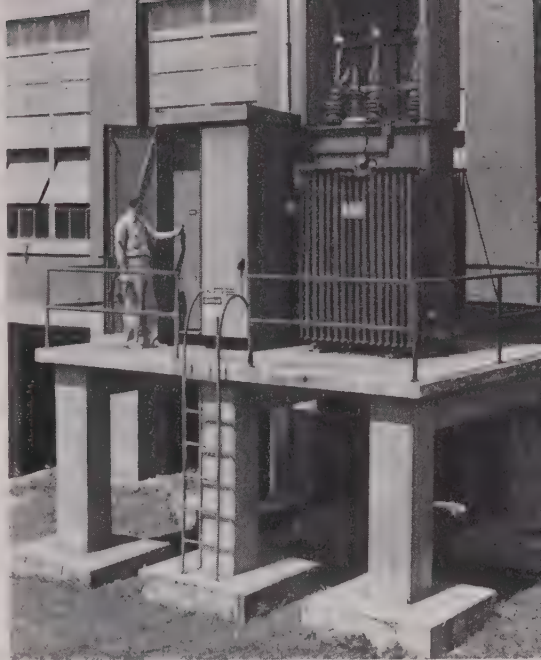
The substations increased production by eliminating shutdowns for repairs and providing the mill with dependable, continuous service.

With the old distribution system, it has been necessary to replace contacts on oil-circuit breakers, clean the tanks, and renew the oil in them twice a year. All of this work had to be accomplished on an overtime basis on week ends, when the mill was not operating, which resulted in considerable extra expense.

These co-ordinated substations are located in small, out-of-the-way areas near the load. Feeders average from only 200 to 250 ft in length compared with feeders of 800 to 1000 ft required by the old distribution system. Line losses have been reduced as a result and constant, accurate voltage regulation is obtained.

The substations are equipped with drawout-type circuit breakers which can be readily interchanged.

These substations are located outside a section of the mill built over a creek bed which heavy rains flood almost every



An operator throws the switch on a 1000-kva outdoor load-center unit substation in use at a large Southern textile mill

spring. For protection during these flood periods, the substations are mounted on 13½ by 16-ft reinforced concrete bases raised about ten feet above the ground. Protection for the top bushings of the substations is provided by a three-sided metal screen. The equipment is totally enclosed and kept locked at all times, thus assuring safety to the personnel.

Application of the theory is expected to be of great value in amateur, short-wave, and other types of long-distance broadcasting where no definite radio frequencies are assigned and there is congestion noise or other types of interference.

In the crowded radio amateur bands the "ham" may use the method to select a sideband on the other side of a frequency on which he is encountering interference. In shortwave or overseas radio transmission, single-sideband reception will cancel out one sideband of a radio signal and permit the remaining one to get through clearly. In the same way, transmitting on one sideband will aid the sending of a clearer radio signal.

A type of single-sideband transmission has been used by the armed forces and other agencies for some time; however, development of the new method paves the way for the first simple and inexpensive application of the theory. Previous equipment used many tubes in massive cabinets; equipment based on the new development will be relatively simple in design.

Solution of the problem in the past was to use a filter as a sieve, eliminating one of the sidebands as it passed through electronic transmitting or receiving equipment. Such filters, design and construction of which few have mastered, have been built to operate at carrier radio frequencies up to 125 kilocycles.

Although home-radio application of the sideband principle is indefinite at the moment, much improved reception would result from it, since the worst effects of fading would be eliminated.

Nonmetallic Cable

A new nonmetallic sheathed cable has been developed especially for use on farms because it withstands weather extremes, fumes, corrosive vapors, and most fungi.

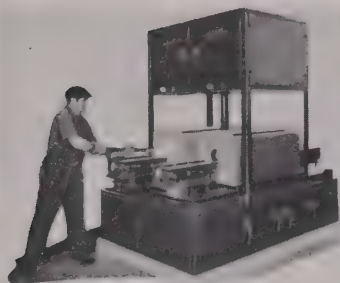
Built to meet service conditions encountered in livestock and dairy barns, chicken houses, and other locations where conventional nonmetallic cables break down, the new cable, known as Super PVX, is also resistant to flames, moisture, oils, acids, alkalies, impact, and abrasion.

The cable's conductors are encased in thermoplastic insulation which is wrapped first in paper, then in glass braid, and finally in a smooth, durable, ivory or brown thermoplastic sheath that does not mar, flake, or mark walls or hands.

Use of this type of insulation results in a smaller, lighter cable that can be used to surface-wire summer cottages, roadside restaurants, and similar structures without spoiling their decorative effect.

Approved by Underwriters' Laboratories for installation wherever non-metallic cables are allowed, the new cable is available with either two or three conductors in 14, 12, and 10 gage.

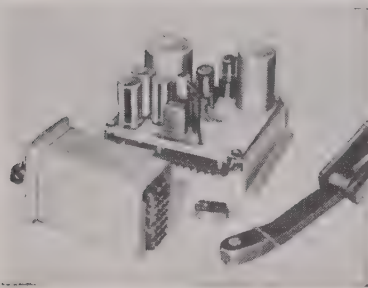
NEW PRODUCTS: AND WHAT THEIR MAKERS HAVE TO SAY ABOUT THEM



Induction Heater

Induction Heater

A new Ajax-Northrup induction heater designed to eliminate waste caused by attempts to forge bars that have cooled too much during preliminary operations. The heater speedily reheats a bar the few hundred degrees required to bring it back to the proper forging temperature. Located at the forging machine, the heater turns out one bar every 60 sec, timed to the forging operation. Cooled bars are fed onto rollers to the high-frequency induction furnace where they are reheated on an automatically timed heating cycle to emerge at the exact forging temperature desired. The unit has twin heating coils, each of which draws 125 kw of power at 960 cycles. Power source is a 700-kw 960-cycle 400-volt motor-generator unit.—*Ajax Electrothermic Corp., Trenton 5, New Jersey.*

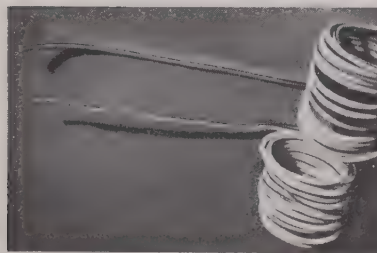


Diamond-stylus Pickup

Diamond-stylus Pickup

A diamond-stylus variable-reluctance pickup, with either a 2.5- or 3-mil radius, and associated transcription equipment for its use by broadcast stations. A lateral-reproducing type, the pickup provides a usable frequency response over a range from 50 to 10,000 cycles. Elimination of resonant peaks and substantial discrimination against noise due to vertical pickup contribute also to its applicability to broadcast use. The transcription arm is designed especially for lateral reproduction, with no design compromises to accommodate vertical transcription as well.

Built for use with standard 16-in. transcriptions, movement on the vertical and horizontal axis is smooth because it is equipped with cone-face ball bearings. The transcription equalizer provides a four-position equalizer for flat, N.A.B., good records, and poor records.—*Transmitter Division, General Electric Company at Electronics Park, Syracuse, N. Y.*



Thermoplastic Tubing

Thermoplastic Tubing

Thermoplastic tubing, and similarly insulated wire, features integrally extruded contrastingly colored striping which imparts a permanent codifying identity in circuits and other conductor elements. Striping effects obtained by conventional ink-imprinting processes necessarily subject themselves to a loss of identification through fading and the effects of everyday wear and tear. The integral process of imparting the striped effect with the same extrusion material, in contrasting colors, not only insures a permanency of identification, but precludes the possibility of any impairment of the dielectric factor of the insulating tubing or insulated wire.—*William Brand & Co., 276 Fourth Ave., New York 10, N. Y.*

Safety Goggles

Safe-T-Vis, a new type of safety goggle, is made of an allyl casting resin, a new kind of plastic providing extra surface hardness. This material combines the lightness, comfort, and added safety features of plastic and at the same time resists surface scratchings. Since one of these plastic lenses is approximately one-half the weight of a case-hardened glass lens, workers can wear them without discomfort throughout the period of exposure. These lenses are available in four goggle styles and in a selection of sizes. *The Univis Lens Company, Dayton 1, Ohio.*

A new midget relay, Type 119XBX, for electric vending machines combines dependable operation with ease of mounting and wiring. The relay has double-pole double-throw contacts rated 5 amp. The operating coils can be supplied for any a-c voltage up to 115 volts, 60 cycles. Relays for 115 volts are adjusted to operate at as low as 85 volts as a safeguard against non-operation of a machine when under lowered voltage conditions.—*Struthers-Dunn, Inc., 150 N. 13th St., Philadelphia 7, Pa.*

Material Racks

Newly designed automatic material racks constitute a material handling system for machine operations, progressive assembly, storage, and transporting of materials. These automatic spring-powered racks hold a visible bank of material and bring pieces to the operator's hand level as a preceding piece is handled. The same working level is constantly maintained, and flow of material is timed to each worker's individual capacity. Being activated by self-contained springs, the rack requires no outside power source and its action is smooth and quiet. Provision is made for convenient adjustment of spring power to adapt the units to load changes.—*American Machine & Foundry Co., 485 Fifth Ave., New York 17, N. Y.*

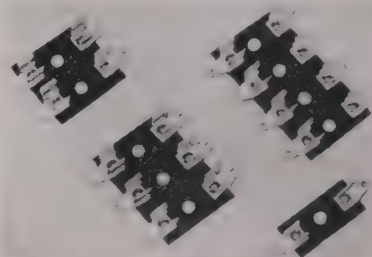
Photoelectric Wattmeter

A new photoelectric recording wattmeter designed for such applications as analyzing welding circuits and measuring industrial heating load, motor-starting load, and power surge can be used to measure d-c or a-c power up to 10,000 cps.

The wattmeter, which has a linear scale, is available for portable use or for semiflush mounting. Chart speeds from 1/2 in. per hr up to 72 in. per min can be obtained by using different combinations of chart carriages and rate gears. When the instrument is calibrated for a particular frequency, accuracy is ± 3 per cent. When calibrated for 60 cycles, it can be used over the entire range from 60 to 10,000 cycles at unity power factor with an error of ± 5 per cent. The power-factor error when going from 0.5 lagging to 0.5 leading is only ± 3 per cent.—*Meter & Instrument Divisions, General Electric Company, West Lynn, Mass.*

Fuse Clips

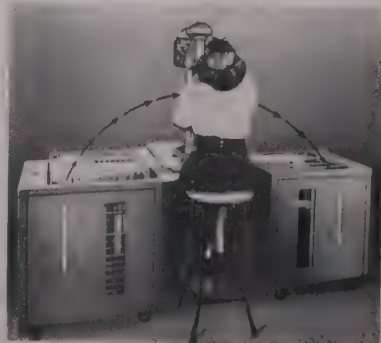
Solidly based one-piece fuse clips for 3 AG fuses, with integral terminals that are tinned for soldering, are available in 1-, 2-, 3-, and 4-fuse banks from stock; other sizes can be made to order. Sample will be furnished on request.—*American Molded Products Co., 1652 N. Honore St., Chicago 22, Ill.*



Fuse Clips



Midget Relay



Material Racks

Filter Lenses

Duoweld filter lenses afford protection for welders' eyes by eliminating glare which often makes it impossible for the welder to see his work clearly. These lenses are divided into two parts: the lower two-thirds portion is darker and denser than the upper third. This bifocal-like arrangement permits the welder—simply by lowering his eyes and looking through the lower portion of his helmet window—to deflect the glare and see his work distinctly. The metal and the arc crater both stand out in clear detail.

The lenses are tinted blue-green and meet governmental specification for absorption in the infrared and ultraviolet regions of the spectrum. They are recommended for aircraft construction, air transport maintenance, and in all other work where special alloy steels are welded.

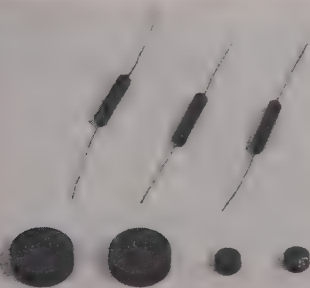
Plates for welders' helmets are available in size 2 in. by 4¼ in. in standard shades 8, 10, and 12.—*Fish-Schurman Corp., 230 East 45th St., New York 17, N. Y.*

Paint Scraper

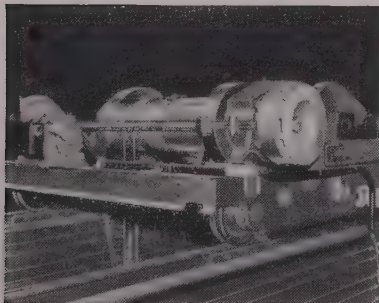
As the newest member of the Red Devil family of tools, this Carboloy paint scraper removes all kinds of paint, varnish, lacquer, and enamel from both flat and curved sheet metal surfaces. The specially designed blade of Carboloy cemented carbide, a metal actually approaching the diamond in hardness, is held in the rust-proof scraper handle with a set screw. The four working edges of the blade—plus the four individually shaped corners that fit into practically



Paint Scraper



Thermistors



Crane Control

any corner or molding—give the scraper a wide range of uses. The new tool scrapes faster and cleaner than steel scrapers and stays sharp at least 100 times longer. In spite of its hardness, the carbide blade will not injure sheet metal under the paint.—*Carboloy Co., Inc., Detroit, Mich.*

Bushings

New durable insulator bushings and sleeves have been made of Nylon and Styron to utilize the dielectric features of these materials. The ease of assembly, low moisture absorption, and shape-retaining characteristics provide electronic and radio industries with a low-cost high-quality component having a wide range of uses. They are available in lengths of ¼ in. to 1½ in., with O.D. from 0.187 to 0.188 in. and I.D. from 0.126 to 0.128 in.—*American Molded Products Co., 1652 N. Honore St., Chicago 22, Ill.*

Truck and Table

Two new pieces of equipment are offered for material handling: an elevating table fitted with casters and a ramp-and-winch arrangement adapted to a hydraulic lift truck.

The adjustable pedestal of the table is capable of handling 2000-lb loads, and the platform, which can either be locked in one position or allowed to revolve freely, elevates from 28 in. to 44 in. Ample stability, even for off-center loads, is provided by the substantial 30 in. by 30 in. base.

By means of a winch and cable, cases weighing up to 6000 lb can be drawn up the ramp and on the truck platform for easy transportation. If the cases are to be stored, the truck is elevated four inches, blocks are placed under the overhanging sides of the case, the truck is lowered and removed, and the case rests on the supports. In this position, the case can easily be moved back on the truck again.—*Lyon-Raymond Corp., Greene, N. Y.*

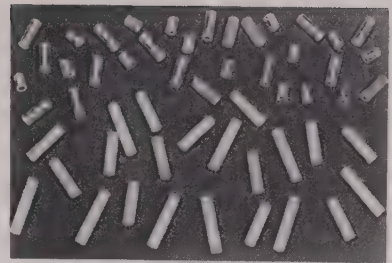
Thermistors

Small electrical semiconductors called Thermistors respond to temperature variations as small as one thousandth of a degree C. They are made from mixtures of semiconducting metallic oxides and possess a high negative temperature coefficient. These devices, made in the form of rods, disks, and beads, are especially adaptable as the sensitive element in flow meters, time delay relays, switching devices, and other types of indicators and controls or as precision elements in aircraft engines, chemical- and food-processing equipment, air-conditioning systems, and domestic appliances.

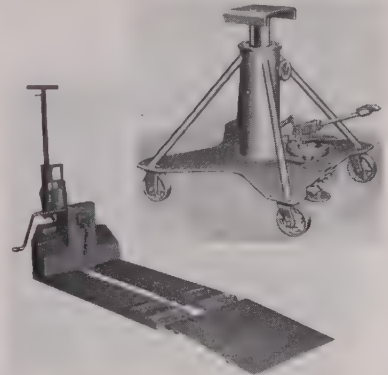
By means of systems employing these devices, temperature variations can be transmitted automatically to distant locations. In this manner these devices are finding applications in meteorological work where they enable an operator to study several different temperatures at once.—*Metallurgy Division, Chemical Department, General Electric Co., Pittsfield, Mass.*

Crane Control

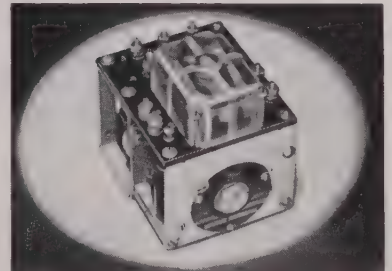
A new a-c crane control, called Magnetorque, provides hoisting smoothness and accuracy, and eliminates mechanical load brake. This simple unit through which braking forces are exerted magnetically governs the action of the hoist motor which is directly connected through the crane gear train to the hoist drum. The hoist motor drives the load both up and down, but it cannot be energized until the magnetic unit has been excited.—*Harnischfeger Corp., Crane Divisions, 4400 W. National Ave., Milwaukee 14, Wis.*



Bushings



Truck and Table



Time-delay Relay

Time-delay Relay

A new a-c timing relay designed expressly for use in processing, machine-tool, signal, sound, and other control equipments or systems where an adjustable time delay, after closing the pilot circuit, is required for proper remote, automatic, or sequential operation. Essentially, the relay consists of a small synchronous motor, a differential gear system, a built-in brake assembly, a trip-switch assembly, an accessible terminal board, and an auxiliary relay. It is also equipped with a safety locking device, preventing any unintentional change in time setting.

By proper external connection of jumpers to the relay terminal board, two different timing sequences can be obtained. With one set of connections "delayed make" with a maintained pilot circuit is provided. The other set of connections permits "instantaneous make" and "delayed break" with a momentary contact pilot circuit.—*Ward Leonard Electric Co., Mount Vernon, N. Y.*

Band Saw

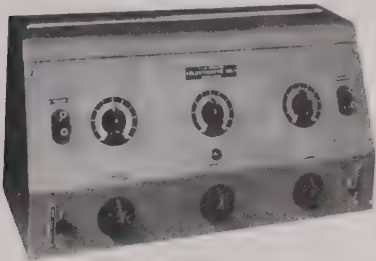
A new 12-in. band saw features a spiral blade offering new possibilities in the cutting and working of all types of wood, plastics, bakelite, and nonferrous metals. Instead of having one cutting face, this blade cuts material from all sides, utilizing the full 360 deg of its surface. This round blade is capable of cutting in any direction—backwards or forwards, right or left. Because of the versatility of the spiral blade, design cutting is not limited to the depth

NEW PRODUCTS (Continued)

of the band-saw throat. Thus, work can be cut without the necessity of rotating the material, making the cutting of intricate designs easy. No chipping or tearing is involved in the cutting operation; even the softest rubber is left with a firm, clean edge.—*Tyler Co., Santa Monica, California.*

Pulse Generator

The new, Model 471, pulse generator has an output consisting of rectangular-shaped voltage pulses internally triggered for continuous operation from $\frac{1}{2}$ to 1000 cps, a continuously variable pulse duration of 25 to 950 microseconds, and a maximum output, into a 10,000-ohm load, of 50 volts. Pro-



vision is made for the use of an external triggering device which can be the type 208 oscilloscope or any source of positive pulses of at least 20 volts. There is also a position provided for generating a single pulse each time the switch is depressed. A three-step range switch and a single fine control provide ample spread adjustment for each of the pulse frequency, pulse duration, and amplitude ranges.—*The Electrodyne Co., 899 Boylston St., Boston 15, Mass.*

Electronic Area Meter

A new electronically operated area meter is said to accurately measure the more viscous liquids, such as black liquor, tar, chemicals, distillates, and refrigerants, as well as freer flowing liquids, such as water, oil, gasoline, etc. This flow measuring instrument consists of a specially designed telemetering transmitter connected to an electronic receiver. The transmitter is easily installed in the pipe line, much like a valve. The transmitter is designed with spring loading, especially suited for marine or mobile service, or with weight loading, for use where the weight chamber can be installed on a true vertical axis.

Some advantages are: installation is simplified because the recorder is constructed of package electronic components which do not need to be carefully leveled, and which are not affected by vibration; the recorder can be calibrated to read in terms of volumetric units, thereby reducing errors due to density changes; and two transmitters can be connected to the same recorder to measure the ratio, sum, or difference of two flows.—*Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.*

Ignition Transformer

A new standardized transformer designed for oil-burner ignition systems features a single-slot end mounting and built-in radio-interference suppression. Convenient low-voltage knockouts are provided on sides, end, and bottom. The new unit has plug-type high-voltage bushings and a large, accessible low-voltage junction box. Strong mechanical construction and complete protection of low-voltage coils are furnished by a steel junction-box partition.

The mechanical features of this transformer fit many present oil-burner designs.—*Specialty Transformer Divisions, General Electric Company, Fort Wayne, Ind.*

Gamma Radiation Meter

The portable 247A gamma-ray survey meter is of the ionization-chamber type and combines stable operation with sturdy construction. Four ranges of sensitivity are provided, and the instrument is calibrated to read in roentgens over full-scale readings of 2.5, 25, 250, and 2500 milliroentgens per hour. The case is watertight, and both the meter and the ionization chamber are hermetically sealed. An eccentric range switch is provided with a color code to give visual indication of the range at which the survey meter is



set. Die castings have been used, wherever possible, to assure the strength required in arduous field service. The handle permits easy balance; total weight of the instrument is 11 $\frac{3}{4}$ lb.—*The Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.*

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TRADE LITERATURE

Combustion Safeguard—Systems for monitoring burners on various applications to protect gas- and oil-fired furnaces, ovens, boilers, kilns, and other heating equipment against explosion hazards. System diagrams illustrate installation possibilities of the equipment. Twelve pages. Bulletin F1-1.—*Wheelco Instrument Co., 847 W. Harrison St., Chicago 7, Ill.*

Electric Counters—Numerous illustrations show the mechanical operations involved in electric-counter applications for counting parts, cartons, cases, and boxes. Also shown are photoelectric actuation and operation with specially designed actuating switches. Sixteen pages. Bulletin ES-91.—*Production Instrument Co., 708-18 W. Jackson Blvd., Chicago 6, Ill.*

Rheostats—Enamelled round rheostats from 50 to 500 watts are described in specification charts which give diameter, angle of rotation, total resistance, maximum current, and standard mounting information. Also included are illustrations of housings for table and switchboard mounting. Four pages. Catalog No. 4.—*Rex Rheostat Co., Baldwin, Long Island, N. Y.*

Thermocouple Wire—Tables of characteristics, application, and selection of thermocouple wire are given in two companion bulletins. One folder contains emf-temperature and temperature-emf tables for copper-copric, iron-copric, chromel-copric, chromel-alumel, and platinum-platinum 10 per cent rhodium; the other describes thermocouple application, selection, wire listings, special wires, and wire identification. The former, Bulletin GET-1415, has 24 pages; Bulletin GEA-4881, eight pages.—*Apparatus Dept., General Electric Co., Schenectady, N. Y.*

Metallic Lead Products—This brochure on current developments and improvements in the employment of lead-lined products, chemical apparatus, and in lead construction is a section taken from the treatise "The History and Origins of Lead Metallic Products." The purpose of the brochure is to present information which has a business, technical, and research significance not generally known to executives or technicians. Twelve pages.—*Knapp Mills, Inc., 121 Broad St., New York 4, N. Y.*

Solvents—Information on flash points, boiling ranges, chemical constitution, and toxicity of solvents for metal cleaning are given to provide selection of the correct solvent for a particular job. Ten pages. Entitled "Actusol and Solvent Information."—*The Dubois Co., Cincinnati 3, Ohio.*

Electrolytic Processing—Copper-oxide rectifiers and controls for electroplating, anodizing, electrocleaning, electropolishing, and other electrolytic processes are described and illustrated. Diagrams and tables listing ranges of manually and automatically controlled rectifiers are also given. Twenty-eight pages.—*Appliance and Merchandise Dept., General Electric Co., Bridgeport 2, Conn.*

Textiles—This two-color brochure, containing 26 photographs, lists many uses for asbestos textiles in industry and the home, and gives detailed descriptions of asbestos roving, lap, yarn, cloth, clothing, safety curtains, tubing, and cord. Sixteen pages. Entitled "Asbestos Textiles."—*Johns-Manville, Box 290, New York 16, N. Y.*

Inert-arc Welding—What the welding process is, the results of its application, and the equipment used in administering it are described and illustrated in this folder which presents photographs of welded joints, typical units to be welded, and several types of welders. Eight pages. Bulletin GEA-4930.—*Apparatus Dept., General Electric Co., Schenectady, N. Y.*

Molded Parts—Powder metal parts, self-lubricating bearings, collector rings and commutator rings, and semiconductors are the subjects of this folder. Their applications and characteristics are described. Four pages. Entitled "Keystone Precision Molded Products for the Electrical Industry."—*Keystone Carbon Co., 1935 State St., Saint Marys, Pa.*

Speed Changers—Miniature units for instruments, controls, regulators, or any small power devices are described. Readily available speed ratios are listed with unit dimensions given. Four pages. Bulletin No. 100.—*Merton Instrument Co., 432 Lincoln St., Denver 9, Colo.*

Electronic—Of interest to dealers and service men, this bulletin gives information on four new units: FM signal generator; combination tube tester and FM and AM signal generator; multitester; and tube tester. Each unit is described and illustrated, and specifications are given. Four pages. Bulletin No. 132.—*Radio City Products Co., Inc., 152 West 25th St., New York 1, N. Y.*

Electrical Insulation—Given in this handbook are the physical characteristics and active formulas of impregnating and dipping waxes, capacitor end seals, and many others. The five methods given for testing these materials are: ring and ball softening point; melting point drip method; cold-flow temperature; pouring temperature; and viscosity. Twenty-four half-size pages. Entitled "Compounds."—*Mitchell-Rand Insulation Co., 51 Murray St., New York 7, N. Y.*

Radio Equipment—A new and general catalog, superseding all others, lists and describes the current line of instruments, parts, and accessories. The catalog is amply illustrated, with photographs and specifications. Two hundred and thirty pages. Catalog L.—*General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*

Electrical Components—In this manufacturer's catalog are covered such items as capacitors, rectifiers, resistors, switches, vibrators, and welding tips and holders. Eighty-two pages. Catalog No. 1.—*P. R. Mallory and Co., Inc., Indianapolis, Ind.*

STOP UNNECESSARY FUSE

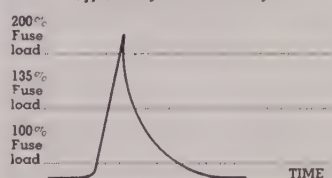
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1. Link Design
2. Screen Ventilation

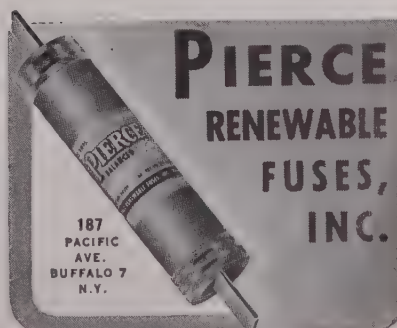
Typical High overload surge



NOTE: The elapsed time at 200% fuse load is a few seconds, but at 135% load may be many minutes.

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FREE: Balanced Lag Link to inspect and test. Specify amperage, voltage.



BOOK REVIEWS

(Available books may be purchased through the GENERAL ELECTRIC REVIEW for domestic delivery; none sent on approval.)

Nomography

Alexander S. Levens—John Wiley & Sons, Inc., New York. 1948. 184 pp. \$3.00.

The methods of nomography have long been recognized as a useful aid to the engineer, physicist, and statistician. While many books have been written on this subject, the textbook by A. S. Levens constitutes a worthwhile contribution to the field by nature of the clear and concise manner in which the material is presented.

The method of geometrical analysis is used to derive the construction formulas for the various nomograph forms; the material is logically presented according to the generalized mathematical formulas that each nomograph form will solve. The book is enhanced by the liberal use of examples and the large collection of exercises appended to each chapter—these are grouped according to the several fields of engineering and applied science.

The use of determinants in constructing alignment charts is briefly treated in the last chapter of the book and serves only as an introduction to this method, which is adequately covered by other writers.

The book concludes with an appendix consisting of a collection of typical alignment charts used to solve practical problems in the various fields of applied science. This constitutes a valuable asset to the book since it illustrates the many modifications and forms that can be used to obtain the most advantageous alignment chart for a particular problem.

K. O. STRANEY

Organic Chemistry

(Third English Edition)

Paul Karrer (Translated by A. J. Mee)—Elsevier Publishing Co., Inc., New York. 1947. 957 pp. \$8.50.

This new English edition of Prof. Karrer's text follows closely the chemistry and subject matter of previous editions. The author states that "passages have been rewritten to bring them into line with results of recent investigations." The literature of organic chemistry has been taken into account approximately down to the end of 1945. As in previous editions, the author has placed emphasis on proof of structure, chemistry of natural products, and biochemical topics. An excellent presentation of the general principles of classical organic chemistry provides lucid treatment for the student. Advanced students will find frequent references to the original literature as well as to more complete texts on particular phases of organic chemistry.

Many typographical errors appearing in the second English edition have been corrected and the text has been more efficiently arranged. The mathematical equal signs used in chemical equations have been replaced by arrows, obviating the confusion of the equal signs with double bonds in the chemical formulas. Changes in electronic formulation have brought many formulas more into line with recent theory. The enlargement of the text has been minor, as the emphasis has been placed on revision. The most significant additions have been in those phases of organic chemistry of special interest to the author. The industrial chemist will find that many important commercial processes and compounds have been given a very limited discussion in Prof. Karrer's book. A small appendix showing

the electronic formulation of oxonium and related substances has been made by transferring this matter from the text.

The book is highly recommended for students and chemists as an excellent revision of an already well-known text.

JOHN K. WOLFE

New Developments in Ferromagnetic Materials

J. L. Snoek—Elsevier Publishing Co., Inc., New York. 1947. 144 pp. \$2.50.

This booklet is one of a series of Monographs on the Progress of Research in Holland during the War. It is a highly technical report, to be recommended only to those engineers and research workers particularly interested in magnetic phenomena and materials. The theory predicts that if one prepares materials in which the crystal anisotropy and the magnetostriction constant are both zero, these materials will show extremely high initial permeabilities, low coercive forces, and low hysteresis losses. A systematic study of the crystal anisotropy and the magnetostriction constant of the binary and ternary systems using commercially available metal elements led the Dutch research workers to the well-known materials, Sendust and permalloy. One new material, nickel with 19 per cent of manganese, has these two constants equal to zero; as a result its initial permeability is high (8000 gauss per oersted) and the coercive force is low (0.04 oersteds).

Dr. Snoek and his associates have developed a group of ferromagnetic materials which are also electrical insulators. These are cubic ferrites prepared by mixing various proportions of two powdered metal oxides with powdered Fe_2O_3 and sintering the mixtures at temperatures ranging from 1100 to 1400 °C. MgO , ZnO , CuO , NiO , FeO , CoO , and MnO may be used. The highest initial permeability (4000 gauss per oersted) was obtained in a ferrite (Philip's trade name, Feroxcube 4) of 15% NiO , 35% ZnO , 50% Fe_2O_3 . To the reviewer's knowledge this booklet is the most complete report on the preparation and properties of these interesting materials.

The sintered ferrites are of particular interest to the electronics engineer because, when subjected to alternating fields, these

materials are practically free from eddy currents and so show low losses at all frequencies below approximately ten megacycles. Their magnetic saturation value is not sufficiently high (~4000 gauss) to make them useful for power transformers and machines.

A great variety of other magnetic phenomena are described, most of which are somewhat academic.

V. C. WILSON

Mechanical Behavior of High Polymers

(High Polymers, Vol. VI)

Turner Alfrey, Jr.—Interscience Publishers, Inc., New York. 1948. 595 pp. \$9.50.

This is a serious attempt to correlate the mechanical behavior of high polymers with fundamental physical principles and with the molecular architecture. Such a treatment shows clearly the great progress that has been made in the past decade and should inspire further serious research in this interesting and important field.

Chapter A deals with the concepts involved: geometry of stress and strain, theory of elasticity, Newtonian and non-Newtonian flow, combinations of elasticity and flow, and modern concepts of fluid flow.

Chapters B, C, and D are the heart of the book. They deal with the elastostatic behavior of linear and cross-linked polymers as affected by the amorphous, or crystalline, character of the polymer being considered. The argument is usually carried to the point at which all the significant principles which have a bearing on the point under discussion have been examined and their relative importance stressed.

Chapter E deals with the effect of low-molecular-weight materials (plasticizers), or linear polymers, and also briefly with solutions of such polymers. It is to be hoped that in a later edition the author will deal more comprehensively with the problems of plasticization and possibly omit entirely the section on solutions.

Chapter F, dealing with ultimate strength of polymers, must have been the most difficult to write. The approach is frankly empirical.

The book is a must for all who are working in this field and will help many who are doing routine physical testing of polymers to understand the significance of the methods they are using and also something of their lack of reliability.

A. L. MARSHALL

Crystal Rectifiers

Henry C. Torrey and Charles A. Whitmer, Office of Scientific Research and Development, National Defense Research Committee—McGraw-Hill Book Co., Inc., New York. 1948. 457 pp. \$6.00.

The authors of this volume, No. 15 of the M.I.T. Radiation Laboratory Series, have compiled an excellent summary of the work done upon point-plane rectifiers in the United States and in England during the past seven years. While working at the Radiation Laboratory they obtained a vast amount of information from universities and industrial organizations. They have arranged this information carefully, added their own theories, and interpreted the data in an excellent fashion. As far as the reviewer knows, it is the only book of its kind on this subject.

General properties of semiconductors are reviewed in some detail. Existing theories



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—*Richard Fleming
Consulting
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BOOK REVIEWS (continued)

are correlated with experimental data wherever possible. The general theory of frequency conversion is outlined, using matrix algebra to simplify the expressions obtained. Conversion loss, noise, burnout, and associated test equipment are considered in detail with reference to microwave converter crystals. Manufacturing techniques are described for all types of crystal rectifiers mentioned.

Special types of point-plane rectifiers are considered in the final section. These include the high-inverse-voltage germanium diode, the low-level detector, and the welded-contact germanium rectifier.

The authors have made every effort to include all available information upon the subject and to allocate fairly credit for inventions and development. The book has the reviewer's unqualified recommendation to all interested in semiconductors as well as to those seeking more specialized information on point-plane rectifiers.

H. Q. NORTH

Most-often-needed FM and Television Servicing Information

Compiled by M. N. Beitman—Supreme Publications, Chicago. 1948. 192 pp. \$2.00.

This is a compilation of servicing notes for forty of the most popular FM and television receivers of 1947-1948. The material was prepared explicitly for radio servicemen and is similar to previous books of the same publisher on servicing home radio receivers.

In general, the data given for each receiver are in the form of a photostatic copy of the manufacturer's service notes for that receiver.

Each section contains all the information usually supplied by the manufacturer for servicemen, including descriptions of special features of the circuits, schematic circuit diagrams, photographs and diagrams of sub-assemblies and location of parts, and specific alignment instructions.

Although intended primarily for servicemen, the book should also be useful to circuit designers and others interested in the practical aspects of FM and television receivers.

H. R. SUMMERHAYES, JR.

Micromeritics, The Technology of Fine Particles (2nd Edition)

J. M. DallaValle—Pitman Publishing Corp., New York. 1948. 583 pp. \$8.50.

Fine particles make up the earth's crust, permeate the atmosphere and, alas, our streams and rivers. Their properties dominate soil science and are vital to industries as far apart as paints and electronics. Dr. DallaValle's avowed purpose is to provide a text in fine-particle technology which may become a standard reference. His first edition to a large extent accomplished this purpose. The second edition contains additional chapters on the diffusion of particles, surface phenomena, smoke and dust clouds, and the theory of sampling. The original material on particle size measurement, size distributions, packings, particles under pressure, particle dynamics; electrical, optical, sonic, and thermal properties; sieving, grading, and grinding has been enlarged. The treatment of dust and separation of particulate matter from air is especially complete and should be of interest to those in the field of air conditioning.

The book is primarily a development of the principles of particulate matter. The direction of practice is indicated and numerous tables of useful data are included, but it can hardly be expected to serve as a handbook of procedure in any particular

application. The author has the happy knack of introducing each subject with clarity and with references to specific examples. The reader may be lulled into a false sense of security to find himself in the middle of a rapidly developed mathematical treatment. The fifteen-page chapter on particles under pressure contains no less than thirty-eight equations. On the whole, however, the material is logically presented, the symbols are clearly chosen, and illustrations are used liberally. Illustrative problems follow each chapter.

CALLAWAY BROWN

Practical Electrical Wiring (3rd Edition)

H. P. Richter—McGraw-Hill Book Co., Inc., New York. 1947. 574 pp. \$3.75.

Richter's book has been revised to include changes brought about by the 1947 National Electrical Code. The most important changes of interest to the frequent reader are in the current ratings of building wires. These changes are reflected in the 15-, 20-, 30-, and 50-ampere branch circuits which now replace the 15-, 20-, 25-, 35-, and 50-ampere circuits of the 1940 Code. Richter's treatment of thermoplastic insulation, known as Type T, should be in the chapter devoted to Types and Sizes of Wire rather than under Code Changes. The new Type T conductor constitutes a large portion of the total output of building wire.

An excellent section has been added on fluorescent lighting; it is commendable in this type of book that the complex theory involved in the production of light through fluorescence has been omitted.

The chapters on Installation of Specific Outlets and Old Work continue to be outstanding in simplicity and of great practical value to both the novice and the experienced workman.

This book is highly recommended to everyone who is concerned with residential, farm, and industrial wiring.

H. H. WATSON

Understanding Vectors and Phase

John F. Rider and Seymour D. Usan—John F. Rider Publisher, Inc., New York. 1947. 153 pp. \$9.99.

The authors of this short book have sought to describe in simple, nonmathematical language the methods and basis for representing the relationships between sine-wave currents and voltages in electrical and electronic networks in terms of rotating vectors; and in this respect they have done an admirable job of presentation.

The subject is discussed from the viewpoint of one who is familiar with the general concepts of steady-state a-c circuit elements and vacuum-tube theory, with little mathematical justification given for the processes involved but with great emphasis placed on physical reasoning and on the "physical picture" obtained by means of vector representation.

The material is developed by first considering the vector representation of physical quantities and then demonstrating this means of representation as applied to sine-wave currents and voltages, by means of considerations based on a simple a-c rotating generator. The concepts of phase difference and relative phase are presented and the methods expanded for the treatment of series and parallel circuits. The general theory of adding, subtracting, multiplying, and dividing vectors is then covered, both graphically and algebraically (without recourse to complex variables); and the treatment logically concludes with the complete vector analysis of several common electronic circuits.

K. O. STRANEY

LIBRARY NOTES

ON ARTICLES IN OTHER TECHNICAL JOURNALS

ANNEALING

Continuous Annealing Nonferrous Strip.

E. S. Kopecki—*Iron Age*, Jan. 8, 1948; v. 161, pp. 46-50.

How employment of an electrical heat source enhances control over temperature conditions, while the "vertical" feature offers substantial saving in floor space.

ARC WELDING

Heliarc Welding for the Difficult-to-weld Metals and Alloys.

H. T. Herbst and F. J. Pilia—*Prod. Engng.*, Jan., 1948; v. 19, pp. 127-131.

Joint constructions, limitations on thicknesses of materials, weld strengths relative to strength of base metals and other information for use in designing.

BEAMS

Integral-equation Approach to Problems of Vibrating Beams.

Walter T. White—*Franklin Inst. Jour.*, Jan., 1948; v. 245, pp. 25-36.

Vibrating members treated as beams are rotating shafts, turbine blades, hulls of ships, airplanes, missiles, and other complex structures.

BERYLLIUM

Beryllium in Magnesium Casting Alloys.

Jay R. Burns—*Tech. Data Digest*, Dec. 1, 1947; v. 12, pp. 5-12.

A paper presented before the Amer. Soc. for Metals.

BRAZING

ABC's of Silver Alloy Brazing.

W. J. Van Natten—*Iron Age*, Jan. 8, 1948; v. 161, pp. 51-55.

Fundamentals that must be observed in using silver alloy brazing as a joining method are outlined in this article along with a description of the characteristics of ten well-known silver brazing alloys.

CAPACITORS

Series Capacitors on Distribution Circuits.

R. E. Marbury and J. B. Owens—*Elec. Engng.*, Feb., 1948; v. 67, pp. 158-162.

A careful analysis of the conditions under which the series capacitor is to operate must be made; maximum and momentary current and by-pass provisions for excess currents must be considered.

COILS

Temperature Coefficient Effects of RF Coil Finishes.

Chester I. Soucy—*Tele-Tech.*, Dec., 1947; v. 6, pp. 52-55, 91, 93.

Analyzing changes in inductance following the use of various products for dust and moisture protection and mechanical stability.

CRYSTALLOGRAPHY

Physical Properties of Crystals and Their Symmetry.

Marcel Tournier—*Elec. Commun.*, Dec., 1947; v. 24, pp. 478-525.

A survey of crystalline substances for such properties as pyroelectricity, dielectric susceptibility, piezoelectricity, elasticity, and piezomagnetism.

DIMENSIONAL ANALYSIS

Dimensionless Groups in Fluid Friction, Heat, and Material Transfer.

A. Klinkenberg and H. H. Mooy—*Chem. Engng. Prog.*, Jan., 1948; v. 44, pp. 17-36.

A mathematical presentation showing the application of the theory to problems in chemical engineering.

ELECTRIC CONDUCTORS

Experiences with Aluminum Electrical Conductors in Aircraft.

B. M. G. Wolfram—*Tech. Data Digest*, Jan. 1, 1948; v. 13, pp. 7-13.

Some of the factors influencing the use of aluminum conductors in aircraft electrical systems.

ELECTRIC HEATING

The Rotary Induction Heater; A New Means of Heating Metals Inductively Prior to Working.

G. Brunner and A. Tschalaer—*Brown Boveri Rev.*, Apr./May, 1947; v. 34, pp. 81-85.

Contrary to the well-known inductive method used on static principles, the eddy currents are induced in the work by rotating d-c magnets. Expensive auxiliaries such as frequency converters and variable condensers are not required.

ELECTROPLATING

Electrodeposition of Tungsten Alloys on Metal Surfaces.

Steel, Dec. 29, 1947; v. 121, pp. 63, 66.

Process developed by National Bureau of Standards deposits thick, smooth coatings that retain hardness at elevated temperatures.

FOUNDRY PRACTICE

Casting Developments in Review.

Foundry, Jan., 1948; v. 76, pp. 66-89, etc.

A group of five articles, by different authors, on foundry practices applying to steel, aluminum, malleable iron, brass and bronze, and gray iron.

GAS FLOW

Mechanics and Thermodynamics of Steady One-dimensional Gas Flow.

Ascher H. Shapiro and W. R. Hawthorne—*Jour. App. Mech.*, Dec., 1947; v. 14, pp. A317-A336.

A mathematical analysis.

GAS TURBINES

Aeroplane Gas Turbines.

Hayne Constant—*I.M.E. Proc.*, War Emerg. Issue no. 29, 1947; v. 157, pp. 202-204.

A short article on the general principles.

JET PROPULSION

Development of the Lockheed P-80A Jet Fighter Airplane.

Clarence L. Johnson—*Jour. Aero. Sci.*, Dec., 1947; v. 14, pp. 659-679.

Story of the "Shooting Star."

LUBRICATION AND LUBRICANTS

High-temperature Greases.

H. A. McConville—*Prod. Engng.*, Jan., 1948; v. 19, pp. 93-95.

Factors to consider when selecting and applying greases for high-temperature service.

METAL COATING

Tinning Manganese Bronze.

I. R. Valentine—*Steel*, Jan. 12, 1948; v. 122, pp. 68-71.

Describes difficulties encountered in tinning bearing liners for locomotives.

METAL CUTTING

Tool Angles Govern Cutting Efficiency.

M. Kronenberg—*Am. Mach.*, Jan. 15, 1948; v. 92, pp. 90-92.

How the problems involved may be demonstrated and studied by means of a transparent plastic model.

METALLOGRAPHY

Anomalies in the Appearance of Glide Ellipses.

Robert Maddin—*Metals Tech.*, Feb., 1948; v. 15. Tech. Pub. No. 2332, 6 pp.

Pertains to metallographic studies.

METALS

Temperature Transitions in Ductility of Steel.

Wendell P. Roop—*Weld. Jour.*, Dec., 1947; v. 26, pp. 748s-752s.

The words "temperature transition" refer here specifically to the shift in medium steel from behavior in the ductile mode at higher temperature to that in the brittle mode at lower temperature.

MICROCHEMISTRY

Micro-spectrochemistry of Aluminum Alloys.

D. P. Jensen—*Iron Age*, Jan. 8, 1948; v. 161, pp. 66-68.

A spectrographic microchemical analysis technique.

MICROPHOTOGRAPHY

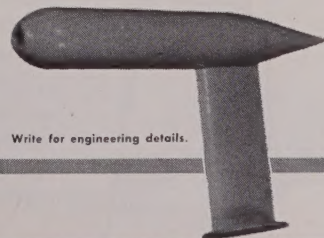
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Ernest P. Taubes—*Elec. Mfg.*, Jan., 1948; v. 41, pp. 76-80, 166, 168, 170.

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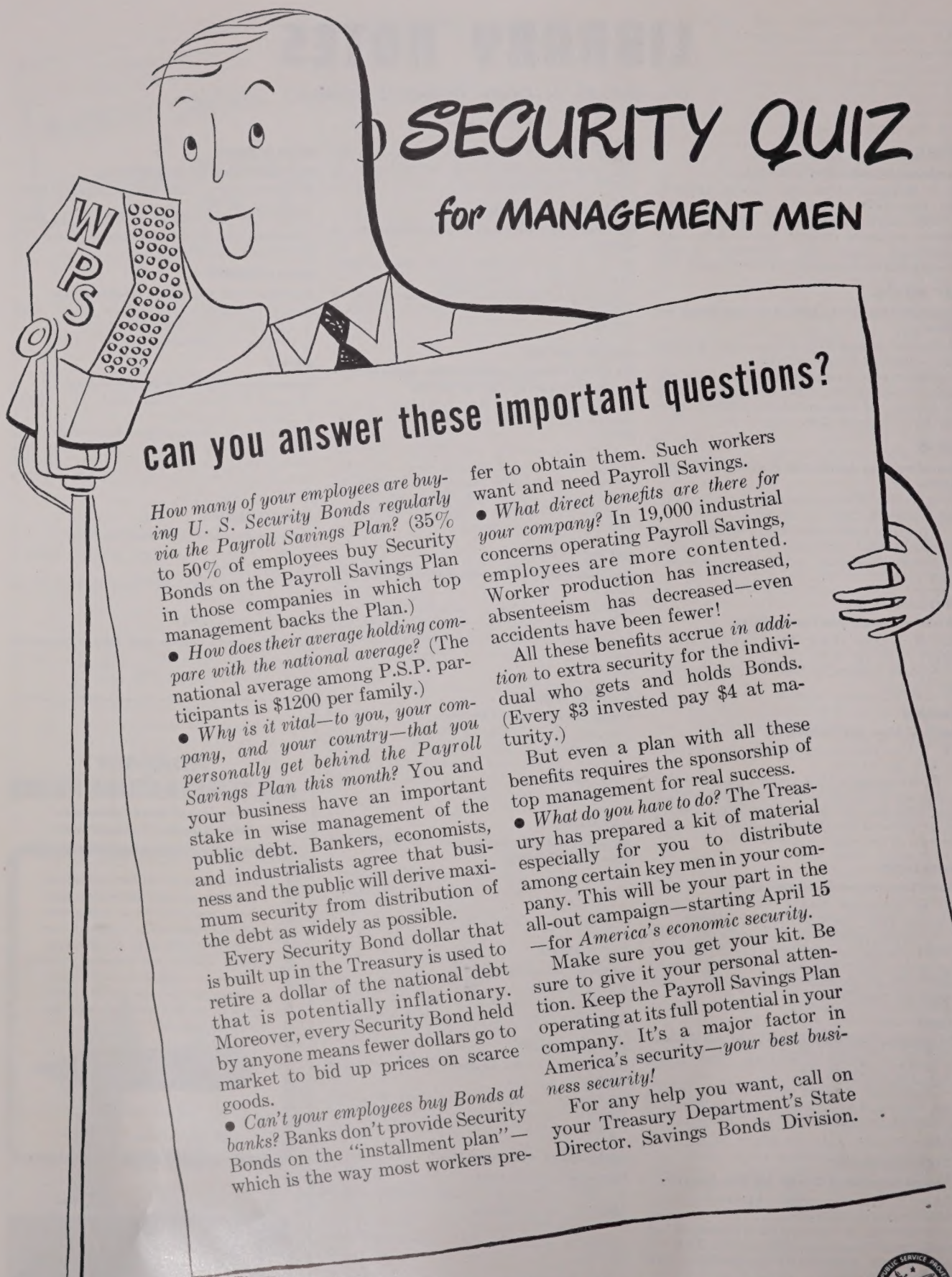
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PLASTICS—TESTING

New Interpretation of Heat Distortion Data of Plastics.
L. S. Moody and K. B. Goldblum—*A.S.T. M. Bul.*, Jan., 1948; pp. 55-58.

The graph of the log of deflection in mils versus the log of the absolute temperature, with regard to heat distortion data.

POTENTIOMETERS

An A-c Potentiometer.

J. M. Vanderleck—*Elec. Engng.*, Feb., 1948; v. 67, pp. 173-181.

An a-c potentiometer of the rectangular co-ordinate type has proved acceptable from the standpoint of both reliability and accuracy.

PRESSURE VESSELS

Alternative Form of Pressure Vessel of Novel Laminar Construction.

H. Birchall and G. F. Lake—*I.M.E. Jour. & Proc.*, Dec. 1947; v. 156, pp. 349-367 (Proc.)

Describes the design, construction, and testing of these vessels and makes observations on the cost aspect and the future possibilities.

PROTECTIVE APPARATUS

Fuse and Relay Co-ordination Improves Rural Line Service.

G. F. Sargent—*Elec. Lt. & Pr.*, Dec., 1947; v. 25, pp. 58-62, 64.

Experience gained in the use of relay-operated oil circuit breakers on rural feeders serving fused tap lines is presented here, together with a step-by-step analysis of the cascaded co-ordination required to make this type of protection practicable.

RADIO ENGINEERING

Shunted-amplifier Input Admittance.

A. Shadowitz—*Elec. Commun.*, Dec., 1947; v. 24, pp. 468-477.

A method for finding the input admittance of an amplifier having a shunt impedance between its output and input, as applied to the case of a frequency-modulated oscillator.

Audio Distortion Problem.

Ted Powell—*Radio-Electronic Engng.*, Dec., 1947; v. 9, pp. 10-12, 31.

Part I of a two-part article discussing the numerous types of audio distortion, many of which are not considered in conventional distortion ratings of audio components.

SOUND

Vortices and Streams Caused by Sound Waves.

Carl Eckart—*Phys. Rev.*, Jan. 1, 1948; v. 73, pp. 68-76.

Theoretical treatment.

STEEL

How to Live with Bar Stock Shortage.

Benjamin Melnitsky—*Mill & Factory*, Jan., 1948; v. 42, pp. 148-152.

How wastefulness of bar stock may be minimized by reducing such losses as those from machining errors, outdated fabrication methods, "lost" stock, lack of consolidation, and requisitioning practices.

STRAINS AND STRESSES

Stress Analysis by Freezing.

Engng., Jan. 9, 1948; v. 165, pp. 37-38.

An editorial on a method of stress investigation involving the use of loaded models, made of thermosetting resins, which retain their strained condition when cool, even after the load is removed.

TOOL ENGINEERING

Tricky Tooling Cuts Relay Costs.

Paul Bonness—*Am. Mach.*, Jan. 1, 1948; v. 92, pp. 93-95.

Ingenious tooling and automatic feeding and clamping convert standard machine tools into high-production equipment. Methods used producing the Square D Company's thermal overload relays.

TRANSFORMERS

Transformer Temperatures—Graphically.

Paul Narbutovskih—*Elec. Wld.*, Jan. 3, 1948; v. 129, pp. 40-42.

Formulas, charts, and graphical procedure are detailed step-by-step for determining winding temperatures of oil-immersed transformers subjected to complex load cycles.

VIBRATIONS, SUPERSONIC

Ultrasonic Delay Lines. I.

H. B. Huntington and others—*Franklin Inst. Jour.*, Jan., 1948; v. 245, pp. 1-23.

Concerned mainly with the theoretical considerations involved in the general process of ultrasonic propagation. The transducer action is given considerable attention and an equivalent circuit employing a transmission line as an element is demonstrated. Serial.

WELDS—TESTING

X-ray Inspection of Spot Welds.

Robert C. McMaster—*Weld. Engr.*, Jan., 1948; v. 33, pp. 54-58.

Nondestructive radiographic inspection of spot welds can be carried out at any point in the fabrication process and will give rapid and reliable indications of weld quality.

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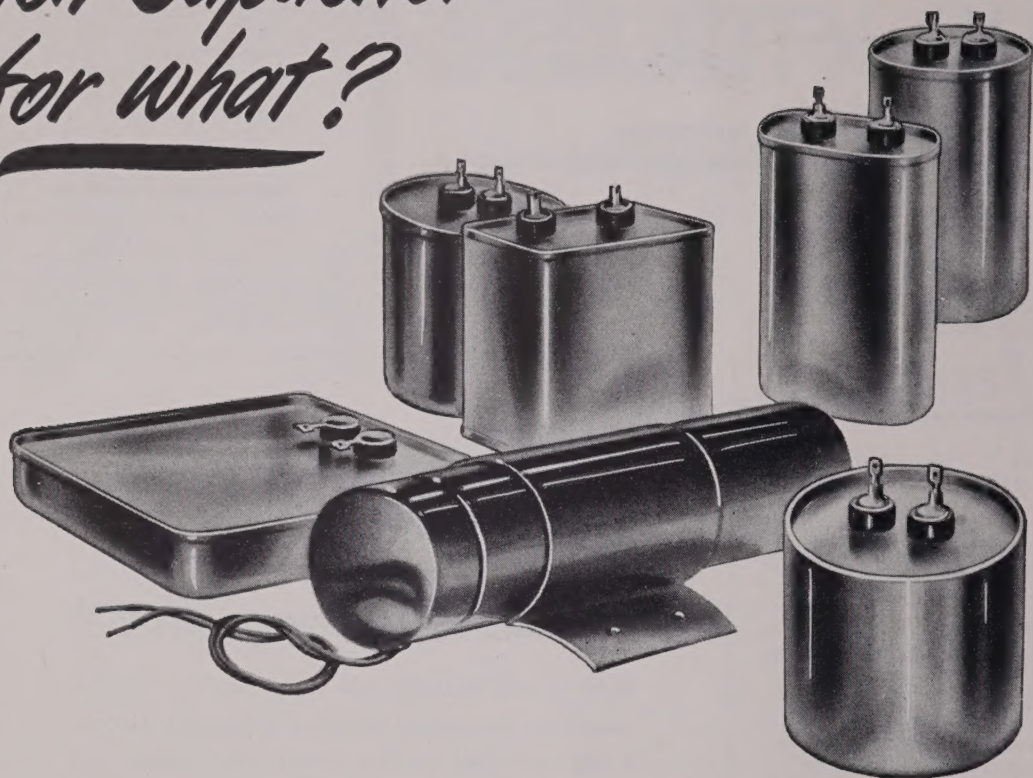
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able to help manufacturers solve an unusual mounting or space problem, and cut their capacitor costs by recommending a unit not normally thought of for the application.

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